TN
1
.M58
v.43
1956

Materials & Methods

Selection & use of

metals, nonmetallics, parts, finishes

in product design & manufacture

January 1956

Wrought Aluminum Alloys—M & M Manual No. 123

Boron Nitride—A New Ceramic

What's New in Porcelain Enamels

Present and Future Uses of Scarce Metals

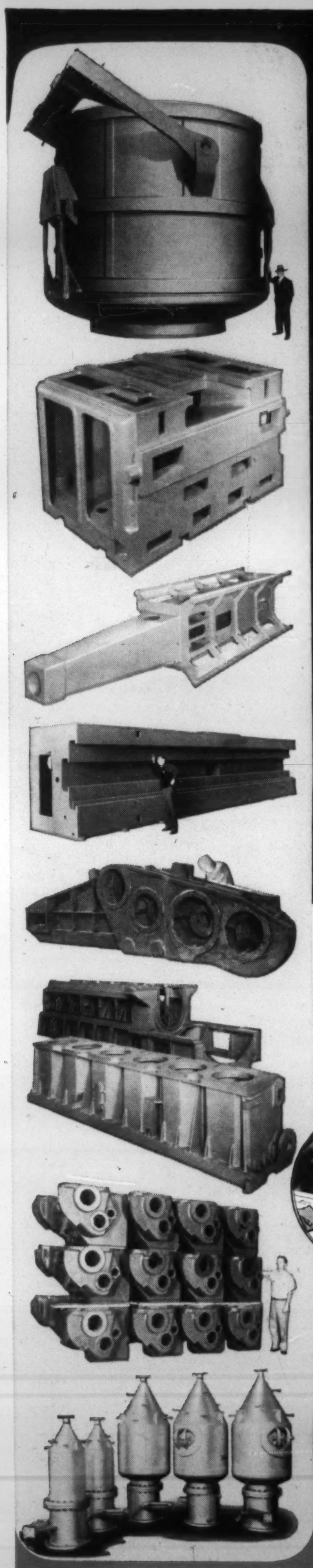
Ceramic Mold Steel Castings

A Universal Glass Finish for Reinforced Plastics

Leaded Forging Steels

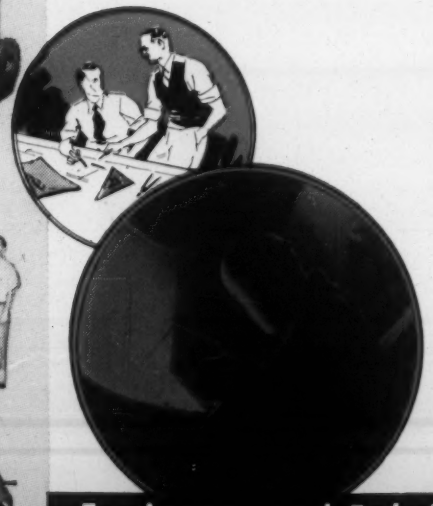
Complete Contents—page 1

PRICE FIFTY CENTS



Steel-Weld FABRICATION

Use WELDED STEEL for Greater Strength with Less Weight!



Illustrated above is one of two Walking Shoes for a large wheel excavator employed in strip mining operations . . . it is one of many heavy parts and assemblies of parts fabricated and machined by Mahon for manufacturers of several types of mammoth earth moving machines. If you can use weldments to advantage in your product, you can turn to Mahon for complete service including design or re-design, fabrication, machining and assembling. Steel-Weld Fabricated parts and products shown at left are typical of thousands produced by Mahon for manufacturers of processing machinery, machine tools, and other types of heavy mechanical equipment. If you need weldments, or welded steel in any form, you will find a unique source in the Mahon organization . . . a source where design skill and advanced fabricating techniques are supplemented by craftsmanship which assures a smoother, finer appearing product embodying every advantage of Steel-Weld Fabrication. See Sweet's Product Design File for information, or write for Booklet showing Mahon's facilities to serve you.

THE R. C. MAHON COMPANY • Detroit 34, Michigan

Sales-Engineering Offices in Detroit, New York and Chicago

Engineers and Fabricators of Steel in Any Form for Any Purpose

MAHON

For more information, turn to Reader Service Card, Circle No. 331

WILLIAM P. WINSOR
Publisher

T. C. DU MOND
Editor

H. R. CLAUSER
Managing Editor
JOHN B. CAMPBELL
Associate Editor
JOHN L. EVERHART
Associate Editor
MALCOLM W. RILEY
Associate Editor
EDWIN M. WEISS
Associate Editor
KENNETH ROSE
Midwestern Editor
111 W. Washington Street, Chicago
GIL MILLER
Art Director
PENNY DREXLER
Editorial Assistant

M. RANDOLPH LONG
Advertising Sales Manager
FRANK J. ARMEIT
Production Manager
RICHARD L. HEAD
Asst. Production Manager
JOHN Y. CUNNINGHAM
Promotion Manager
JOHN N. CARLIN
Circulation Manager
E. M. WOLFE
Manager, Reader Service

Published monthly by
REINHOLD PUBLISHING CORP.
430 Park Avenue
New York 22, N. Y.

RALPH REINHOLD
Chairman of the Board
PHILIP H. HUBBARD
President & Treasurer
K. A. STARKE
Assistant Treasurer
F. P. PETERS
Vice President & Secretary
A. E. FOUNTAIN
Vice President
H. BURTON LOWE
Vice President
MERALD LUE
Vice President
D. BRAD WILKIN
Vice President
WILLIAM P. WINSOR
Vice President

Materials & Methods is indexed regularly in the Engineering Index and the Industrial Arts Index

Materials & Methods®

Selection & use of

metals, nonmetallics, parts, finishes

in product design & manufacture

JANUARY 1956 **VOL. 43, NO. 1**

FEATURE ARTICLES

Present and Future Uses of Scarce Metals ..... *Chester T. Sims* **80**
The transition metals, precious metals and semi-conductors are in demand for electronic parts, nuclear applications

How to Select Floor Covering Materials for Heavy Service ..... *S. Polis* **85**
Simulated service and lab tests used to evaluate 24 different materials

Boron Nitride—A New Ceramic ..... *K. M. Taylor* **88**
Its unique properties include high temperature stability, good electrical properties and excellent machinability

What's New in Porcelain Enamels ..... *John B. Campbell* **92**
Six developments in recent years have greatly extended applications of these coatings

New Nondestructive Test for Magnesium Alloy Castings ..... *G. R. VanDuzee* **98**
Bleed-out penetrant method overcomes many of the disadvantages of fluorescent technique

Ceramic Mold Steel Castings ..... *Edward Vogel* **100**
What they are, their advantages and where they are being used

Leaded Forging Steels ..... *Kenneth Rose* **104**
For easier-to-machine forgings, try these steels

A Universal Glass Finish for Reinforced Plastics ..... *Eric L. Strauss* **106**
Recent tests proved NOL 24 finish good for polyester-glass as well as epoxy and phenolic laminates

Materials at Work **91, 103, 108**
Nickel Tube Wireless Light. Aluminum plus Plastics Honeycomb

MATERIALS & METHODS MANUAL NO. 123

Wrought Aluminum Alloys ..... *Malcolm W. Riley* **109**

ENGINEERING FILE FACTS

Steel Heat Treating Temperatures and Hardness after Treatment **127**

Nomograph Selects Size of Wire for Brazing **129**

DEPARTMENTS

Materials Outlook **3**
Materials Briefs **7**
Men of Materials **9**
Materials Engineering News **11**
Letters to the Editor **14**
Reader Service **67**
Manufacturers' Literature **68**
One Point of View **79**
New Materials Previews **131**
Other New Materials, Products **138**
Contents Noted **173**
News of Engineers, Companies, Societies **200**
Meetings & Expositions **208**
Advertisers and Their Agencies **246**
Last Word **248**

PRICE 50 CENTS A COPY. PAYABLE IN ADVANCE, ONE YEAR, $2.00; TWO YEARS, $3.00 IN U. S., POSSESSIONS AND CANADA. IN ALL LATIN AMERICAN COUNTRIES: ONE YEAR $10.00; TWO YEARS, $16.00. ALL OTHER COUNTRIES: ONE YEAR $15.00; TWO YEARS, $25.00 (REMIT BY NEW YORK DRAFT).

COPYRIGHT, 1956, BY REINHOLD PUBLISHING CORPORATION. PRINTED BY PUBLISHERS PRINTING CO., NEW YORK, N. Y. ALL RIGHTS RESERVED.

REENTERED AS SECOND CLASS MATTER JULY 19, 1951, AT THE POST OFFICE AT NEW YORK, N. Y., UNDER THE ACT OF MARCH 3, 1879. ESTABLISHED IN 1929 AS METALS AND ALLOYS.

OPERATING ADVANTAGES justify wide use of Inconel equipment. In an 8-hour treating cycle, the three Inconel boxes, above, hold heavy loads of silicon steel laminations at 1475°F. They increase output by 50% for Kobzy Tool Company, Chicago. The units are fabricated from Inconel by Chicago Boiler Co., Chicago, Ill.

Wrought Inconel cuts annealing box weight some 75%

Adds years to life, multiplies furnace output

These wrought Inconel* nickel-chromium alloy annealing units weigh only 107 pounds.

Each of them replaces a heavy, cumbersome "pan-type" hood and tray that totaled more than 400 pounds.

Easier to handle, fewer repairs

Moreover, now a serious repair problem is solved. The heavy pans warped and cracked after 3 or 4 heats. In fact, the user, Kobzy Tool Company, had to keep a welder working full time, repairing cracks. Seals failed, too. Often, sand got in and spoiled work pieces. Sometimes furnace gases leaked in and actually fused the work.

When Kobzy called in Chicago Boiler Company, Chicago Boiler answered with the new wrought Inconel design.

Each box consists of grid base, tray and hood. All fabricated from Inconel. This nickel-chromium alloy retains usable strength up to 2200°F. And it resists thermal shock, oxidation, carburization, and hydrogen embrittlement. Yet Inconel is easy to form and machine . . . and easy to weld.

Being lighter, each Inconel unit gets up to heat in less time. Hot gases circulate around the entire box, held above the hearth by a grid base. Thus, heating is more uniform and furnace output substantially increased.

These Inconel units have now served Kobzy about one year. Without a single failure.

Perhaps, you, too, can save money by using Inconel nickel-chromium alloy. Write for a copy of "Keeping operating costs down when temperatures go up." Packed with information, it describes how Inconel helps cut production costs at temperatures up to 2200°F. Send now.

*Registered Trademark

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street New York 5, N. Y.

Inconel ...for long life at high temperatures

INCO TRADE MARK **Nickel Alloys**

For more information, turn to Reader Service Card, Circle No. 376

Materials Outlook

EXPANDED METAL is being produced in meshes as small as 0.015 by 0.030 in. by a French company. The material, available in mild steel, stainless, copper, brass, nickel, aluminum and other metals, is similar to large-mesh expanded metals but is produced on scaled-down equipment. Uses include filter sections in carburetors and grids in radio tubes.

ELECTROLYTICALLY PERFORATED PLATES for filter applications are now being made with uniform openings as small as 20 microns in a variety of metals, and plates with openings as small as 5 microns are under development.

NEW ORGANO-SILICONE COMPOUNDS are said to retain the favorable release, thermal and viscosity characteristics of the dimethyl silicone oils, but provide lubricity and anti-wear properties rivalling those of petroleum oils. Some of the new compounds are water soluble.

A PERMANENTLY TUFTED, RESILIENT FABRIC has been created by utilizing the plastic memory of polyethylene. Monofilament yarn of polyethylene is prestretched, then woven with conventional textile fibers; when immersed in boiling water the polyethylene shrinks considerably, thereby buckling the fabric according to the pattern of the weave. High wear resistance, good ventilation characteristics and good resiliency make the new material promising for auto seat upholstery.

NEW ROUND OF STEEL INCREASES has begun with a $2 per ton hike in the price of cold rolled steel, plus generally upward revisions on extras, by U. S. Steel.

COST OF TITANIUM has dropped again. A major producer recently cut the price of sponge by 30 cents and mill products by amounts ranging from 60 cents to three dollars a pound. New sponge price is $3.45, 30% lower than the price of two years ago.

THORIUM CAN BE GREATLY STRENGTHENED by small additions of carbon, a recent study shows. Tensile strength was doubled by a 0.25% addition and further increased by precipitation hardening and cold working.

CORROSION OF FUEL ELEMENTS in hot water can be studied by a new apparatus. It consists of an autoclave specially designed and fitted with windows to permit taking time-lapse motion pictures of a metal sample.

GRAY MARKET IN NICKEL EXISTS, say many electroplaters. The industry claims that at least one-third of its members—and considerably more in certain areas—must pay three to four times the nominal market price. Its request for government control of the distribution of nickel has, in effect, been rejected by the government.

(Continued on p. 4)

Materials Outlook

ALUMINUM DEMAND will be three million tons a year by 1960, according to top aluminum executives. The current figure is about 2,150,000.

ALUMINUM ENGINE BLOCKS are being die cast experimentally. The 6-cylinder blocks weigh 50 lb when cast and 43 lb when trimmed, compared to about 175 lb for gray iron. It is claimed that they can be produced at the rate of 30-35 per hour on the present machine and at a cost 10% lower than gray iron. A 75-lb V-8 engine block is also planned.

RIGIDIZED TITANIUM SHEET is commercially available. In addition to permitting use of lighter gage sheet, rigidizing increases surface area and thereby promotes more efficient dissipation of heat. It is currently beng used in a jet engine shroud.

RIGID POLYVINYL CHLORIDE TUBING is being used to make lightweight, electrically safe ladders.

MAGNESIUM CASTINGS, by making possible optimum payload-weight ratio and weight distribution, have signifcantly contributed to the phenomenal success of the German Volkswagen car. The 36 pounds of magnesium castings include the two halves of the crankcase (20.5 lb), the two halves of the rear axle and transmission housing (13.5 lb), transmission support bracket, steering gear cover, oil pump housing and camshaft timing gear. Use of cast iron instead of magnesium would have added 7% to the weight of the 1600 lb car.

USE OF MAGNESIUM PLASTER MOLD CASTINGS of magnesium is increasing. Parts now made range from less than 1 oz to more than 100 lb in weight and from less than 1 in. to more than 3 ft in maximum dimension.

MORE PRECISE CERAMIC PARTS — as precise as metal parts — can now be made as a result of work by Bell Labs. Greater precision has been achieved by more careful selection of raw materials, more intimate mixing prior to firing, and new tools and chucking techniques for grinding complex shapes. Eventually, these improvements should result in wider use of ceramics in electrical and electronic equipment.

A LINING MATERIAL FOR POLYETHYLENE CONTAINERS makes it possible to package many products which previously caused trouble by permeating the plastic. Among these products are sun tan oils, cleansing creams, baby oils and lotions, hair tonics and eucalyptol-containing pharmaceuticals.

WIDER USE OF PEARLITIC MALLEABLE castings is reported by the malleable iron industry. Pearlitic malleable can be readily flame- or induction-hardened and its increase in popularity seems to parallel to some extent the increase in use of these surface hardening techniques. Pearlitic malleable is also harder and more wear resistant than ferritic malleable.

Materials BRIEFS

Tin and Viand
Epicures interviewed along the Champs Elysées agree that everything in contact with foods must be tinned. Tin imparts no taste to food, and the introduction of other metals and alloys for kitchen utensils is looked upon askance.

Tiny Tim
Researchers propose the possibility of developing a spring driven generator the size of a watchworks to supply burn-out-proof power for transistorized portable radios, hearing aids, or other communication equipment.

Time Please
Measuring time at frequencies of 24 billion cycles per second, an atomic clock, the Maser, utilizes the energy of ammonia molecules to generate high-frequency radio waves without vacuum tubes.

Slide, Fireman, Slide
In a recently constructed firehouse, stainless steel replaced the traditional brass pole connecting the ground floor with the second floor firemen's sleeping quarters.

Oops!
More sensitive than the human variety, a mechanized stomach is being used to measure changes in the motion of elevators during operation.

Sharper TV
Magnifying chromium-plated scraper blade edges 288x, a TV set helps inspectors check imperfections. Formerly inspectors had to spend the day squinting into a microscope.

New Orange Drafted
Molybdate orange, a brilliant, deep orange pigment approaching a light red in hue has been specified for use in military aircraft because of its high visibility.

Insist on *Prest-O-Lite*
Trade-Mark

Deep-Drawn SHAPES and SHELLS for...

Cups
Receivers
Pressure Vessels
Containers
Other Formed Parts

Made to Your Exact Specifications

- In conventional or unusual contours
- With or without openings, fittings or brackets

Higher Quality—Longer Life

- Extreme uniformity of size, weight, strength, capacity and wall thickness
- Longer service life at lower cost
- Backed by over 35 years of experience and manufacturing skill

LINDE engineers will gladly help you with your designs, specifications and production problems involving cold-drawn shells and shapes or formed metal parts. Just mail the coupon for full information.

LINDE AIR PRODUCTS COMPANY
A DIVISION OF UNION CARBIDE AND CARBON CORPORATION
30 East 42nd Street UCC New York 17, N. Y.
Offices in Other Principal Cities
In Canada: LINDE AIR PRODUCTS COMPANY
Division of Union Carbide Canada Limited, Toronto

The term "Prest-O-Lite" is a trade-mark of Union Carbide and Carbon Corporation.

Linde Air Products Company
30 East 42nd Street
New York 17, N. Y.

Please send complete information about deep-drawn shapes and shells.

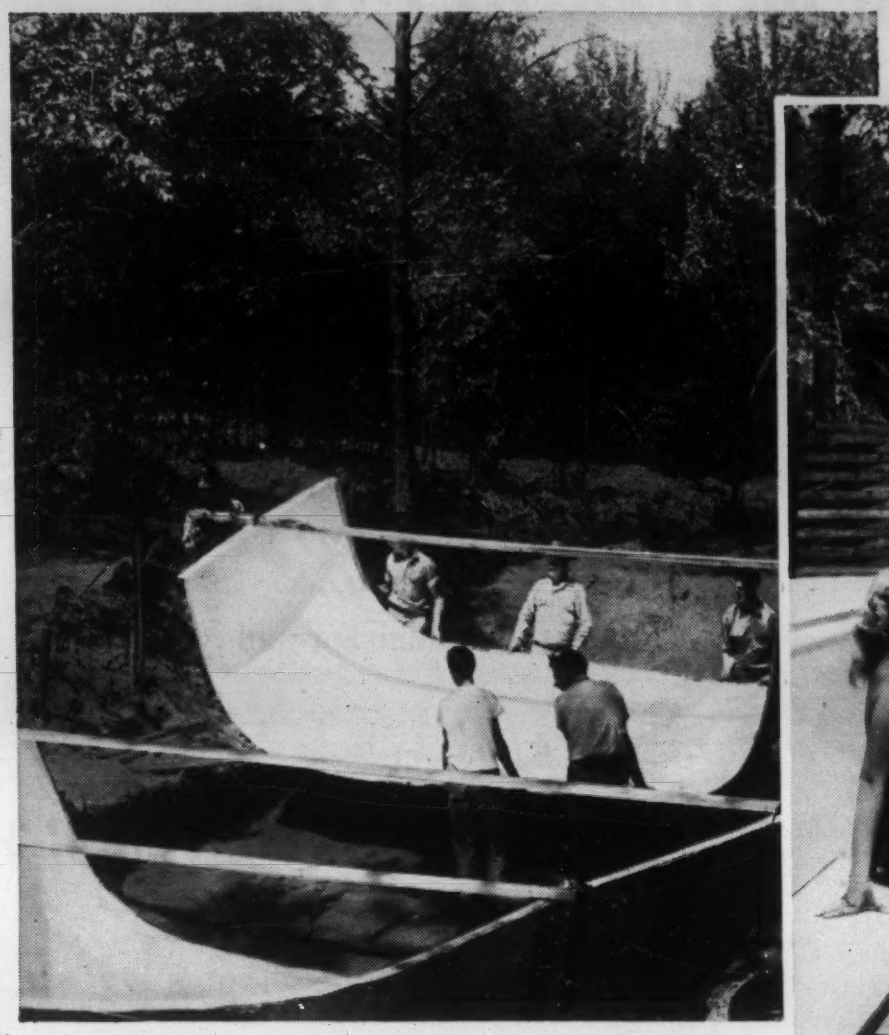
NAME_____

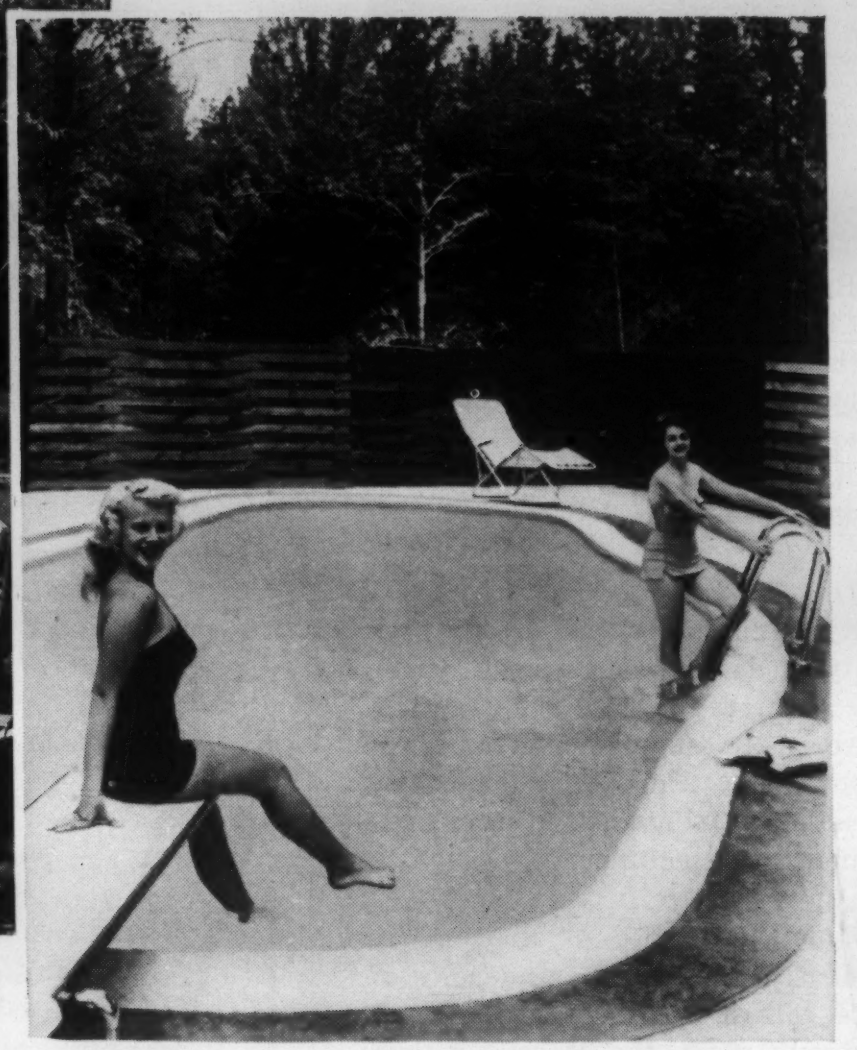
COMPANY_____

ADDRESS_____

For more information, turn to Reader Service Card, Circle No. 387

"Millionaires and movie stars...move over!"





Sections of 42-foot pool made with RCI POLYLITE polyester resin are set in excavation. Overlapping seams are "welded" with resin; then screws are added. With concrete coping set and filter system connected, pool is ready to fill!

Inexpensive, durable swimming pool made with RCI Polylite polyester resin

• The permanent plastic pool you see here makes backyard swimming a practical luxury for thousands of families...practical because of the big advantages in construction of RCI POLYLITE polyester resin reinforced with fibrous glass.

The preformed pool weighs only about 1100 pounds and is easily assembled. It's practically indestructible and has "built-in" color. It's easy to clean, won't leak or crack. And it's highly resistant to chemicals. Pool sections are made by W. R. Chance & Associates in Arlington, Virginia, for distribution by Delorich Enterprises, Inc. of North Miami, Florida.

Perhaps the combination of lightweight strength, durability and easy maintenance you get with RCI POLYLITE and fibrous glass construction can be incorporated into one of your products. Why not find out more about what *you* can do with RCI POLYLITE for laminating, molding and other applications? Write for Booklet A.

Creative Chemistry . . .
Your Partner in Progress

RCI

REICHHOLD

Synthetic Resins • Chemical Colors • Industrial Adhesives • Plasticizers
Phenol • Formaldehyde • Glycerine • Phthalic Anhydride
Maleic Anhydride • Sodium Sulfite • Pentaerythritol • Pentachlorophenol

REICHHOLD CHEMICALS, INC., RCI BUILDING, WHITE PLAINS, N. Y.

For more information, turn to Reader Service Card, Circle No. 357

Men of Materials...

Schulte says:

"Today's designs would benefit by greater uniformity in the quality of current materials."

William C. Schulte has been concerned with the integrity of materials for many years. Now Chief Metallurgist for the Propeller Div. of the Curtiss-Wright Corp., his experience includes work with the A. O. Smith Corp. and the Lukens Steel Co. He has also taught at Lehigh University and at Rutgers University, where he was associate professor in mechanical engineering. He is a former chairman and is a present member of the Advisory Board of the New Jersey Chapter of ASM and is a member of the Aeronautical Materials Specifications Div. and the Iron and Steel Technical Committee of SAE.

"THE traditional task of the aeronautical engineer and designer who specify materials is to get more performance out of less material; this is the key to greater speeds, ranges, and load-carrying capacities. Over the years, however, our ability to do this has been compromised because of a startling lack of uniformity in the quality of the materials we must use. Is this serious? I believe that it is.

"Recently in a series of tests on certain grades of steel we found a direct correlation between fatigue strength and the size and distribution of nonmetallic inclusions. One type of steel, for example, should be capable of carrying a 90,000 psi fatigue load, and much of the material meets this standard. But the hard fact is that not all of the heat can meet this rating. Some of it is 5, 10 or even 15% below par value. One percent of it tested as low as 70,000 psi endurance limit.

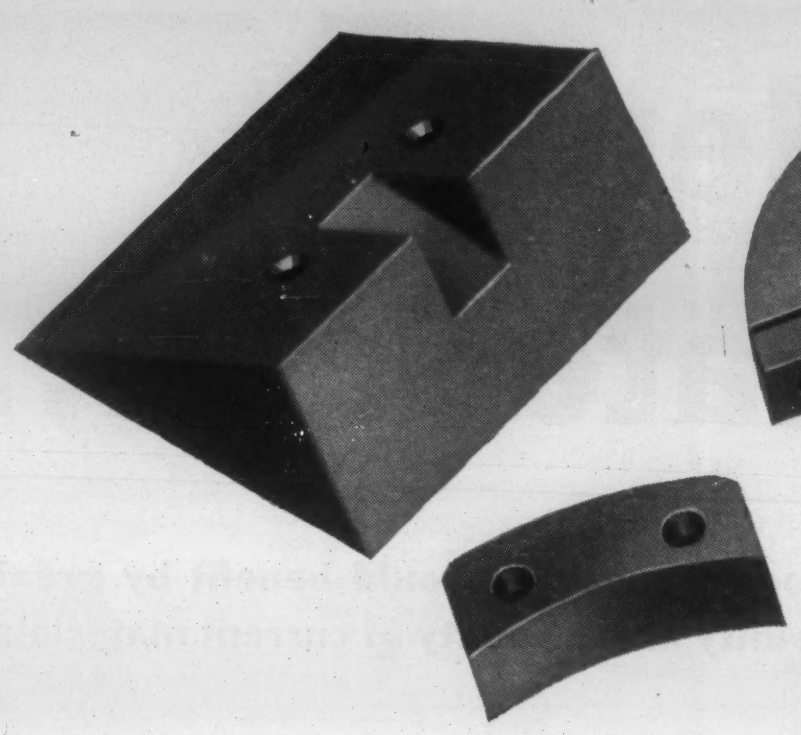
"Because of this, we find ourselves compelled to compromise our maximum abilities to achieve speed and range in favor of the value on which we can properly rely. Most often this is set, not by the average strength of the material, but by its lowest rating.

"In moving to vacuum melted alloys we do find higher strength levels. Yet, according to our tests, there is a spread of variability of as much as 20% within these heats. Our tests of the fatigue strength of the high and super-high strength steels also show an increased spread in variability which will seriously diminish the usefulness of these high strength steels. Again we have to forego the averages or optimums to favor the only dependable strength values. This, of course, effectively cuts down the advantages one expects from these premium materials.

"We feel that producers should take immediate steps to improve uniformity within heats. The producer should recognize that his present materials have serious shortcomings that directly affect the performance of aircraft, and should see the growing need for the utmost uniformity in specialized steels. He should proceed on the basis that this requirement will increase in the future, and may call for entirely new concepts of materials production.

"Meantime, the demands on metals for both military and commercial designs are being increased year after year. A major step in the improvement of aircraft will have been taken as soon as quality and uniformity can be assured in the materials we use."

P.R. MALLORY & CO. Inc.
MALLORY



Mallory 1000 Metal, weighing 16.96 gm/cc, cuts size of counterbalances . . . allows designers to make smaller, lighter aircraft control mechanisms and similar devices.

How to save weight . . . by using heavier metal

MALLORY 1000 METAL Proves Ideal For—

Compact gyroscope rotors

Mallory 1000, with properties especially developed for this service, gives exceptionally high inertia in small space . . . increases sensitivity of gyros.

Smaller radioactive shields

Up to 40% more efficient than lead, Mallory 1000 proves superior for shielding cyclotron and synchrotron radiation, for hot isotope storage, and for radiation switching from source.

Write for technical bulletins.

YOU can reduce the size (and thus the weight) of many control assemblies—housings, linkages, other structural elements—by trimming the dimensions of counterbalances, balance weights, and similar "mass components". High density Mallory 1000 makes this practicable. Twice as dense as steel or brass, and far stronger than lead, Mallory 1000 provides designers with the ideal material for compacting many mechanisms.

Designers will appreciate the high uniformity of characteristics which Mallory 1000 offers. Density, tensile strength, modulus of rupture, and elongation are accurate within narrow limits. You can base accurate design calculations on specific, actual figures—instead of guessing with vague "representative" properties. Mallory 1000 leads all other high density metals in adherence to firm specifications. In addition to its high density and strength, the metal offers ready machinability to high surface finish.

Wherever you need concentrated mass or inertia—in balance weights or rotating elements—it will pay you to look into Mallory 1000. Write for complete technical data.

In Canada, made and sold by Johnson Matthey & Mallory, Ltd., 110 Industry Street, Toronto 15, Ontario.

Serving Industry with These Products:

Electromechanical—Resistors • Switches • Television Tuners • Vibrators
Electrochemical—Capacitors • Rectifiers • Mercury Batteries
Metallurgical—Contacts • Special Metals and Ceramics • Welding Materials

Expect more . . . get more from

P.R. MALLORY & CO. Inc.
MALLORY
P. R. MALLORY & CO., Inc., INDIANAPOLIS 6, INDIANA

For information on titanium developments, contact Mallory-Sharon Titanium Corp., Niles, Ohio

For more information, turn to Reader Service Card, Circle No. 332

MATERIALS ENGINEERING NEWS

Design Engineering Show

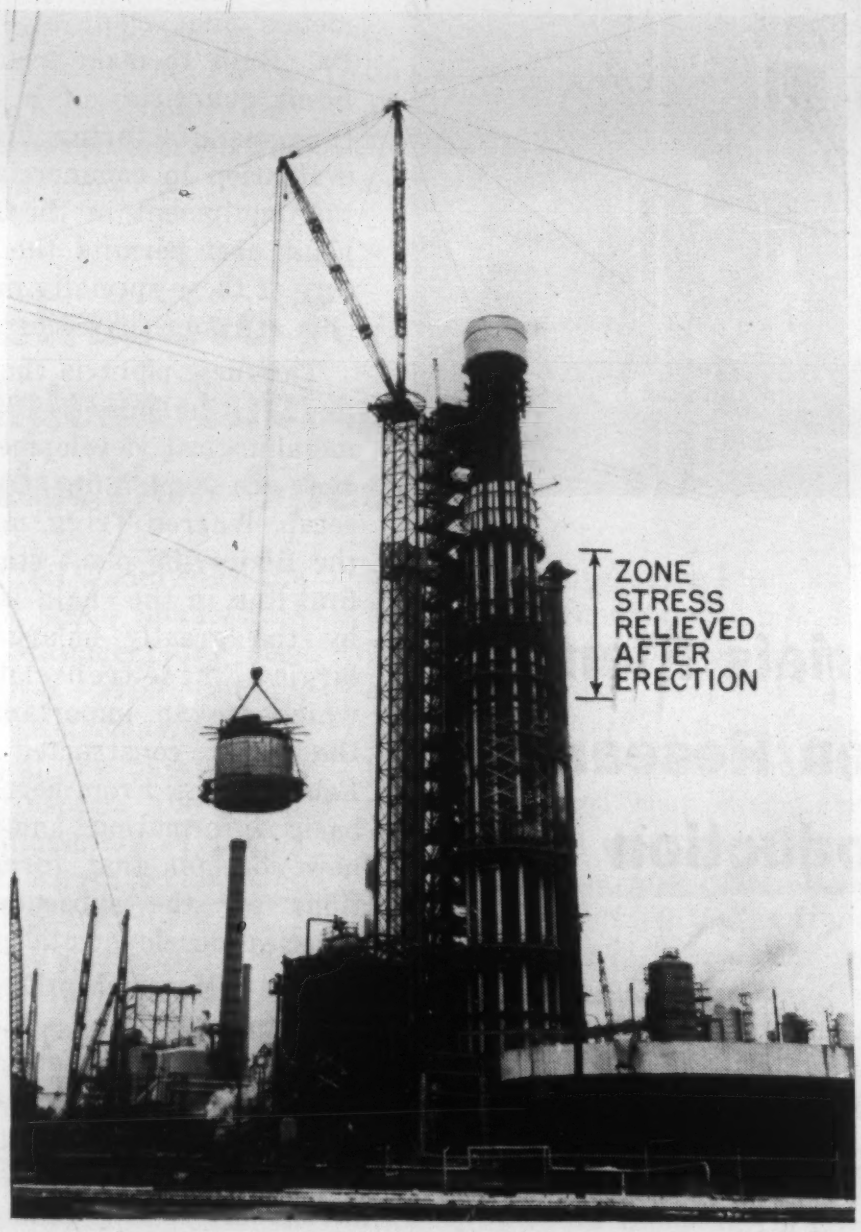
New Materials Plant

Nondestructive Testing

Aluminum Developments

Stainless Steel Survey

Plastics Engineers Meeting



Furnace in the Sky Heat Treats Structure After Erection

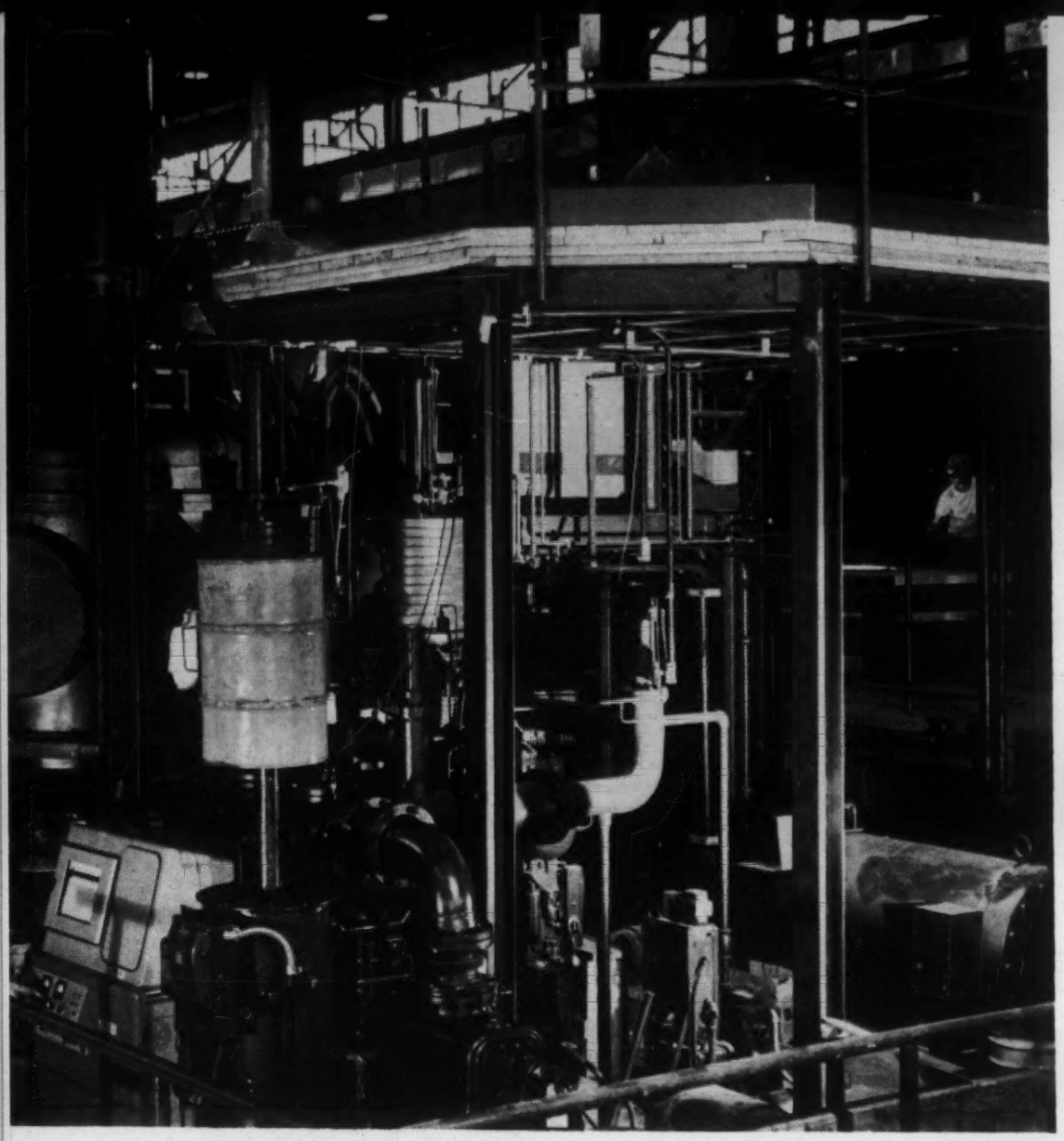
■ Chicago Bridge & Iron had a problem on its hands. In constructing two Houdriflow units for Sun Oil Co., the reactor sections of the units weighed approximately 250 tons — far too heavy to be fabricated as a unit on the ground. Each carried a maze of welded piping, baffles, filters, internal heads, and special structures within its shell of chromium-molybdenum steel clad with 410 stainless. The job plainly called for stress relieving of the welded structure after final erection.

CB&I decided to convert the entire reactor vessel (25 x 71 ft) into a giant "furnace in the sky." Approximately 20 tons of temporary heating equipment capable of liberating 24 million Btu's per hr were hoisted 164 ft above ground level together with insulation and hot gas circulation controls.

Not a small detail was the effect of thermal expansion. In this case, the section being 71 ft tall, total vertical expansion at heat treating temperatures calculated out to about 9 in. Accordingly, CB&I provided slip joints with play in the connection between the hot gas blower and the manhole entrance to the reactor.

The heating cycle was set for 30 hr (12 hr to heat up, 4 hr to hold at work temperature of 1200 F, and 14 hr of controlled cooling). Because the vessel was so internally intricate, some 30 thermocouples were distributed over and within the shell at critical points to check temperature uniformity.

Less than a 90 F temperature variation was noted at the beginning of the 4 hr holding cycle. The ASME code for unfired pressure vessels permits 150 F variation. At the end of the holding cycle the maximum variation was less than 40 F.



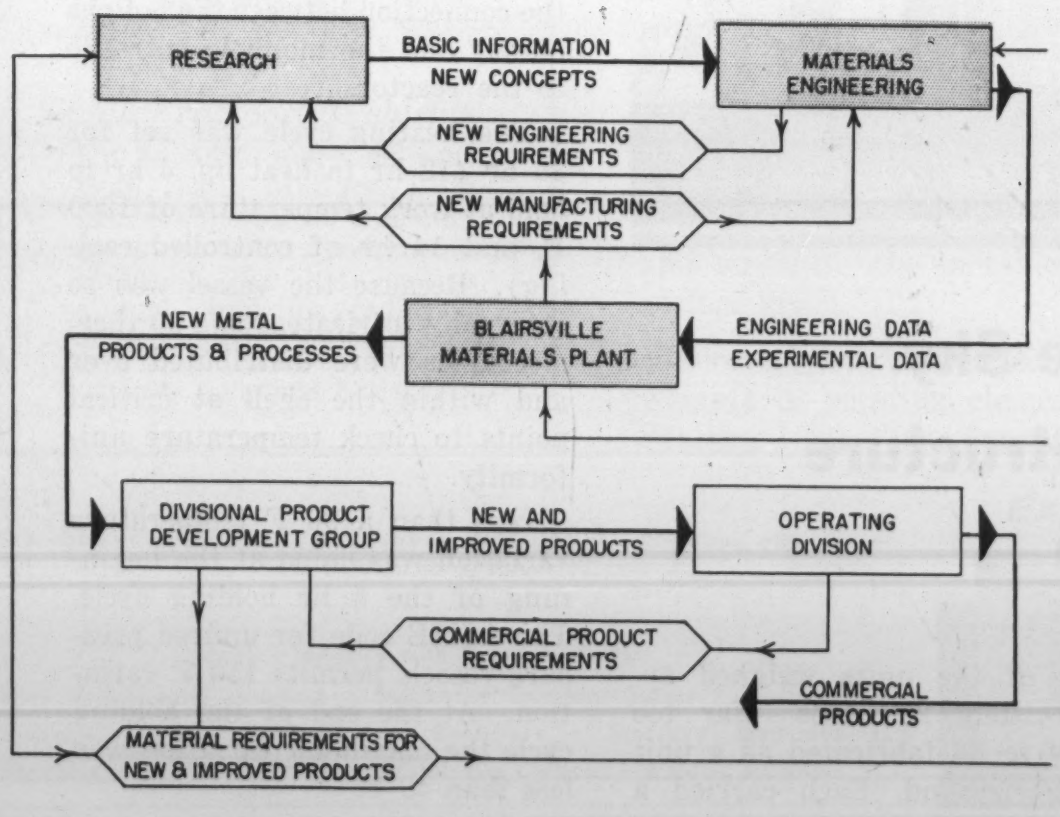
Westinghouse Materials Plant Bridges Gap Between Research and Commercial Production

Avoiding design stops, the inability to improve a product because of the need for a new metal, is a constant nightmare to the development metallurgist. With property demands on metals becoming almost fantastic, there is increasing pressure to close the gap between research laboratory results and practical apparatus applications.

Trying to compress the time between laboratory and commercial production is the object of Westinghouse Electric Corp.'s new metals pilot plant at Blairsville, Pa. Built to make available sufficent quantities of a new alloy to a manufacturing division for evaluation in commercial apparatus, equipment in the Blairsville plant also permits the manufacture of these specialty metal products at competitive costs.

This new plant is the final link in Westinghouse's expanding metallurgical development facilities. In explaining the present setup, Warren Trigg, manager of the Blairsville plant stated, "The first link in the chain is provided by the greatly enlarged metallurgical research laboratories which are an important part of the newly constructed Research Laboratories. From here flows the basic information and radically new concepts that form foundations for the subsequent more practical developmental phases.

"The Materials Engineering Department, the second link, transforms basic information and ideas into more practical engineering form, obtaining the necessary physical data and statistical behavior. After this second phase, a development has usually evolved to sufficient maturity that pilot scale work can begin in the Blairsville plant."



***Vacuum melting installation** (top) at Blairsville plant can accommodate heats ranging from 300 to 2000 lb. Left: Chart illustrates principal links in the metal development setup at Westinghouse Electric Corp.*

Philadelphia Will Be Scene of

Design Engineering Conference

Recognizing the need for a meeting devoted to current design engineering problems, the American Society of Mechanical Engineers is sponsoring a national conference to run concurrently with the First Design Engineering Show. Robert M. Conklin, chief, Mechanical Engineering Division, Battelle Memorial Institute, is chairman of the ASME Machine Design Division which is sponsoring the conference. The conference and show are to be held in Convention Hall, Philadelphia, May 14 to 17, 1956.

The Design Engineering Show is an outgrowth of the Basic Materials Exposition previously held in New York and Chicago.

Editors of the four leading publications in the engineering design field make up the auxiliary papers committee drafting a program for the four day meeting. They are: T. C. DuMond, *Materials & Methods;* Colin Carmichael, *Machine Design;* George F. Nordenholdt, *Product Engineering;* and Frank J. Oliver, *Electrical Manufacturing.*

Tentative program

Cost reduction in product design is the theme of the first day's program with the second day scheduled for a panel discussion on how to find suitable men for the design engineering field and methods of training such men.

Two papers will be presented on the third day. The first will deal

(Continued on p. 210)

Nondestructive Testing of Stainless Tubing at Production Speeds

Carpenter Steel Co. unveiled the latest in high speed nondestructive testing equipment for austenitic stainless steel tubing. Based upon electromagnetic induction testing, the new quality control unit inspects the inside and outside diameters of tubing along the full length and around the entire periphery.

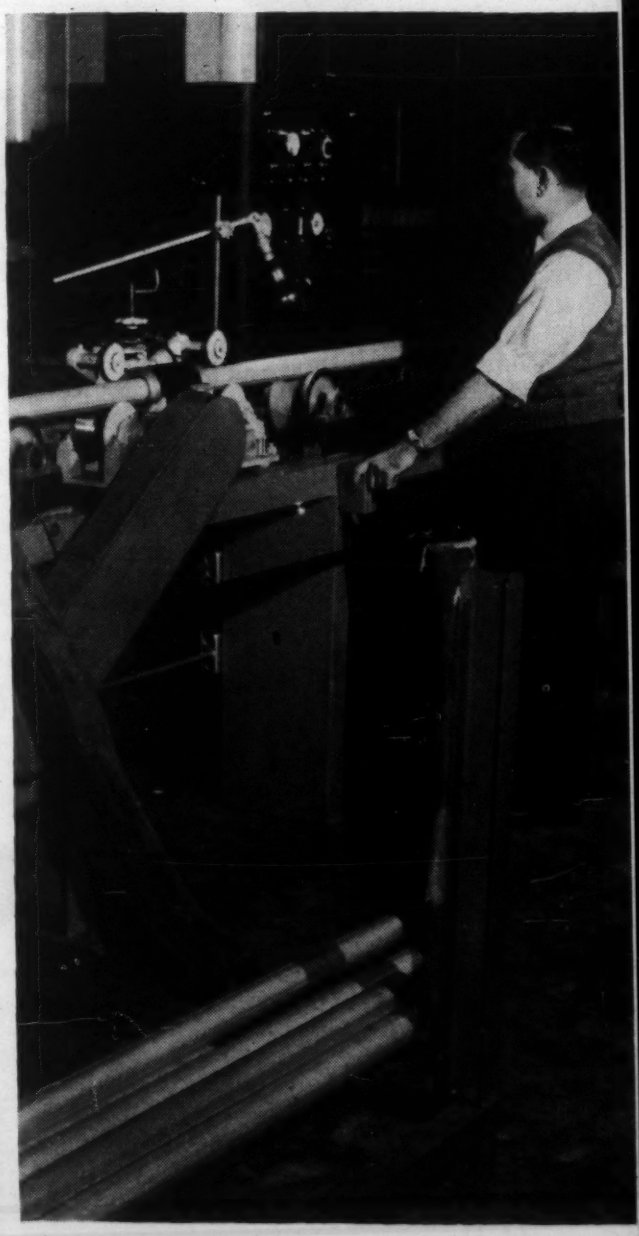
Inspecting at speeds up to 250 ft per min or 15,000 ft per hr, the method surpasses test standards set by ASTM. Showing up changes in wall thickness, and defects such as gouges, splits, inclusions, and weepers, the instrument also detects any variation in chemistry. If, for example, the unit is set up to inspect Type 304 tubing, it will automatically reject Type 316 or any other type submitted for inspection even though they are identical in size, gage, and over-all appearance.

Developed jointly by Carpenter Steel and the Magnetic Analysis Corp., the equipment operates by detecting changes in the over-all resistance to eddy current flow in the tubing. This principle also makes it applicable to titanium, some high temperature steel, and monel. Experiments are now in progress for use on aluminum, copper, and brass.

Carpenter Steel's Alloy Div. is using the tester to check quality aircraft tubing, heat exchanger tubing, and all other small diameter tubing $\frac{5}{8}$ in. and under. It is capable of inspecting tubing from $\frac{1}{4}$ in. o.d. to $3\frac{1}{4}$ in. o.d. and is used on wall-thicknesses up to 0.070 in.

Extremely sensitive, the unit will reveal defects as small as 0.002 in. in depth on small tubing. Sensitivity varies with the wall thicknesses: on 0.065 in. it will detect flaws less than 3% of the wall thickness; on 0.070 in. at 3% of wall thickness; and for thicknesses over 0.070 in. at more than 3% of wall thickness, e.g. at 0.083 in. flaws must be 5 to 6% of the wall thickness to be detected.

In addition to this new testing method, Carpenter Steel still uses the conventional testing procedures required by ASTM specifications: water and air pressure, visual inspection, and destructive tests such as flanging and flaring.



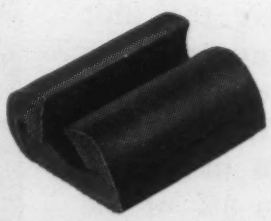
***Nondestructive tester** at Carpenter Steel has audio visual signals that warn operator when defect passes through testing coil. Test results are continuously visible on oscilloscope.*

let **Stalwart** show **you** how **SILICONE RUBBER** can cut fabrication costs!

Industry across-the-board is solving problems, and *cutting costs,* with Silicone Rubber Parts. From access door seals on research rocket planes probing the heat barrier . . . to gaskets for kitchen range oven doors, they are providing the answer. Time and again Silicone Rubber Parts are replacing costly metal constructions forced upon design engineers by the limited thermal stability of organic rubbers.

Because new compounds now retain desirable rubber-like properties at temperatures from −130°F. to +600°F., they play ever-increasing roles in the aviation, automotive, electrical and chemical industries.

STALWART is equipped to produce precision parts from a variety of Silicone Stocks to meet individual, S.A.E., MIL-G or MIL-R specifications.



Parts made from Silicone have excellent dielectric properties and resist compression set, weathering, ozone, oxidation, hot lubricating oils and many chemicals. They can be covered with (or bonded to) a number of synthetic or other materials to provide greater strength or wearing qualities. Let STALWART show you how Silicon Rubber can *cut* your fabrication costs.

6651-SR

STALWART RUBBER COMPANY

MANUFACTURING PLANTS IN BEDFORD, OHIO AND JASPER, GEORGIA
MAIN OFFICES: 165 NORTHFIELD ROAD, BEDFORD, OHIO

For complete information, write today for Catalog 56SR-3

For more information, turn to Reader Service Card, Circle No. 429

LETTERS TO THE EDITOR

Information mart

To the Editor:

In reference to the article, "Finishes for Metal Products," which appeared in the September, 1955 issue, I would like to investigate this subject more fully.

My particular problem is to code a series of small ferrules of commercial bronze by coloring them. These ferrules are electro-tinned and coated with wax. At present we are using a dye in the wax, but the results are very disappointing.

In your article, chromate coatings were mentioned and the fact that they can be converted to a great variety of colors, and I wondered if there is such a finish which could be applied to my problem.

As these parts are used in an electrical function, any finish must be corrosion resistant and have a very low electrical resistance. I would appreciate hearing from you about this subject.

RICHARD GREENBERG
Design Engineer
Thomas & Betts Co., Inc.
Elizabeth, N. J.

To the best of our knowledge, chromate coatings are not applied to copper alloys. There are methods of applying a variety of colors to copper alloys, but none of the coatings are corrosion resistant.

To the Editor:

The June, 1955 issue carried an article called "Finishes for Plastics." This article has a paragraph entitled "Hot Stamping" and discusses stamping with ink applied to a hot die with a felt roller. Victory Manufacturing at present is running six machines hot stamping with roll leaf and has had difficulty stamping roll leaf on certain acetate type plastic injection molded pieces. Therefore, we would greatly appreciate all information and suppliers' names that you could send us concerning ink hot stamping.

R. L. KNIGHT
Finishing Superintendent
Victory Manufacturing
Chicago, Ill.

A list of suppliers' names has been sent.

Complimentary file

To the Editor:

I have just recently become aware of the high quality and excellent service provided by your magazine in many spheres. I am a member of a research group at the United Kingdom Energy Research Establishment who are interested in building a very large cyclotron and, as you know, many different materials and techniques are required in such a project. Your magazine seems to me an excellent

(Continued on p. 220)

reader service

helps you get
up-to-date technical bulletins
and details on advertised products

USE THESE POST-FREE CARDS TO REQUEST . . .

FREE MANUFACTURERS' LITERATURE . . .

from the selected list of new bulletins reviewed on pages following this insert. Under subject headings, you will find a cumulative listing of current technical literature suitable for your reference files. To obtain bulletins, circle numbers on the card.

INFORMATION ON ADVERTISED PRODUCTS

will be forwarded to you if you note the reader service code number appearing with the advertisement, and circle it on one of the cards at right.

WANT M & M MANUALS?

reader service will fill requests for MATERIALS & METHODS Manuals. All Manuals are reprinted as they appear in the magazine and are available for a nominal handling charge. For an order blank and a list of available Manuals, see page 217.

PLEASE NOTE: Because of the large quantity of literature reviews this month, some numbers on reply card normally reserved for advertisements are being used to identify Manufacturers' Literature items.

READER SERVICE DEPT.; Please Send To: January 1956

PLEASE PRINT

NAME _____ POSITION _____

FIRM _____

STREET _____

CITY _____ STATE _____

Manufacturers' Literature No.

											1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110
111	112	113	114	115	116	117	118	119	120	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140
141	142	143	144	145	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160	161	162	163	164	165	166	167	168	169	170
171	172	173	174	175	176	177	178	179	180	181	182	183	184	185	186	187	188	189	190	191	192	193	194	195	196	197	198	199	200
201	202	203	204	205	206	207	208	209	210	211	212	213	214	215	216	217	218	219	220	221	222	223	224	225	226	227	228	229	230
231	232	233	234	235	236	237	238	239	240	241	242	243	244	245	246	247	248	249	250	251	252	253	254	255	256	257	258	259	260
261	262	263	264	265	266	267	268	269	270	271	272	273	274	275	276	277	278	279	280	281	282	283	284	285	286	287	288	289	290

Information on Advertisement No.

301	302	303	304	305	306	307	308	309	310	311	312	313	314	315	316	317	318	319	320	321	322	323	324	325	326	327	328	329	330	331
332	333	334	335	336	337	338	339	340	341	342	343	344	345	346	347	348	349	350	351	352	353	354	355	356	357	358	359	360	361	362
363	364	365	366	367	368	369	370	371	372	373	374	375	376	377	378	379	380	381	382	383	384	385	386	387	388	389	390	391	392	393
394	395	396	397	398	399	400	401	402	403	404	405	406	407	408	409	410	411	412	413	414	415	416	417	418	419	420	421	422	423	424
425	426	427	428	429	430	431	432	433	434	435	436	437	438	439	440	441	442	443	444	445	446	447	448	449	450	451	452	453	454	455
456	457	458	459	460	461	462	463	464	465	466	467	468	469	470	471	472	473	474	475	476	477	478	479	480	481	482	483	484	485	486
487	488	489	490	491	492	493	494	495	496	497	498	499	500	501	502	503	504	505	506	507	508	509	510	511	512	513	514	515	516	517
518	519	520	521	522	523	524	525	526	527	528	529	530	531	532	533	534	535	536	537	538	539	540	541	542	543	544	545	546	547	548
549	550	551	552	553	554	555	556	557	558	559	560	561	562	563	564	565	566	567	568	569	570	571	572	573	574	575	576	577	578	579
580	581	582	583	584	585	586	587	588	589	590																				

Students and foreign subscribers (other than Canadian), please request literature directly from manufacturers.

This card not good after March 1.

FIRST CLASS
PERMIT NO. 1538
(SEC. 34.9 P.L.&R.)
NEW YORK, N. Y.

BUSINESS REPLY CARD
No Postage Stamp necessary if mailed in the United States

4¢ POSTAGE WILL BE PAID BY—

MANAGER, READER SERVICE DEPARTMENT

MATERIALS & METHODS

430 PARK AVENUE
NEW YORK 22, N. Y.

MANUFACTURERS' LITERATURE

New Literature

TRADE SHOWS

DESIGN ENGINEERING SHOW. Clapp & Poliak, Inc. Literature, for both visitors and exhibitors, describing the Design Engineering Show—to be held in Philadelphia, May 14 to 17—as well as free admission tickets for visitors. (1)

METAL POWDER SHOW. Metal Powder Association. Literature for both visitors and exhibitors describing the Metal Powder Show—to be held in Cleveland, April 10 to 12. Free admission tickets. (2)

Alloy Steels. Armco Steel Corp., 32 pp, illus. Brochure gives a graphic description of quality controls from raw material to finished steels. (3)

Powder Brass Alloys. Dixon Sintaloy Inc., 1 p. Lists properties of powder metal brass alloys and features parts fabricated from each. (4)

Powder Metals. Supermet Div., Globe Industries, Inc., 6 pp, illus. What to know about solid parts made from powder. (5)

Ductile Iron. The International Nickel Co., Inc., 28 pp, illus. Listing of typical applications of ductile iron castings in various industrial fields. (6)

Malleable Iron. Malleable Founders' Society, 4 pp, illus, No. 52. New facts on the uses of malleable iron are given. (7)

Titanium. Metal Hydrides, Inc., 2 pp, No. 600-C. Data sheet on titanium metal and facts on storage and handling. (8)

Reinforced Plastic. Minnesota Mining & Manufacturing Co., 20 pp, illus. Advantages, applications and procedures for using Scotchply reinforced plastic. Gives pricing information and detailed property charts. (9)

Anodized Aluminum. Sandoz Chemical Works, Inc., 2 pp, illus. Samples of color anodized aluminum with description of physical properties. (10)

Laminated Metals. Standard Metals Corp., illus. Fact file on the application of composite metals in the electronic and electrical industries. Engineering data on physical properties included. (11)

Bronze Alloys. Waterbury Rolling Mills, Inc., 60 pp, illus. Information and physical data on nickel-silver and phosphor-bronze alloys in sheet, strip and coils. (12)

Tungsten Carbide. Adamas Carbide Corp., 4 pp. Different grades of tungsten carbide for various uses described and tabulated. (13)

Ultrasonic Soldering. Aeroprojects, Inc., 15 pp, illus, No. SB-5. Sonobond equipment for fluxless soldering and for metal coating. (14)

Carbon Dioxide Welding. Air Reduction Sales Co., 13 pp, illus. Carbon dioxide shielded consumable electrode arc welding described with operating characteristics and specific properties. (15)

Data Sheets. Allegheny Ludlum Steel Corp. Data sheets on a new series of steels for various uses. (16)

Resins for Paints. Barrett Div., Allied Chemical & Dye Corp., 8 pp. Plaskon coating resins for paints, varnishes, lacquers, and allied products. (17)

Wire and Strip. Alloy Metal Wire Div., H. K. Porter Co., Inc., 4 pp. Data on precipitation hardening stainless steel for spring applications. (18)

PLEASE NOTE: Because of the large quantity of literature reviews this month, some numbers on reply card normally reserved for advertisements are being used to identify Manufacturers' Literature items.

FIRST CLASS
PERMIT NO. 1538
(SEC. 34.9 P.L.&R.)
NEW YORK, N. Y.

BUSINESS REPLY CARD
No Postage Stamp necessary if mailed in the United States

4¢ POSTAGE WILL BE PAID BY—

MANAGER, READER SERVICE DEPARTMENT

MATERIALS & METHODS

430 PARK AVENUE
NEW YORK 22, N. Y.

READER SERVICE DEPT.; Please Send To: January 1956

PLEASE PRINT

NAME _____ POSITION _____

FIRM _____

STREET _____

CITY _____ STATE _____

Manufacturers' Literature No.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81
82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108
109	110	111	112	113	114	115	116	117	118	119	120	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135
136	137	138	139	140	141	142	143	144	145	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160	161	162
163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178	179	180	181	182	183	184	185	186	187	188	189
190	191	192	193	194	195	196	197	198	199	200	201	202	203	204	205	206	207	208	209	210	211	212	213	214	215	216
217	218	219	220	221	222	223	224	225	226	227	228	229	230	231	232	233	234	235	236	237	238	239	240	241	242	243
244	245	246	247	248	249	250	251	252	253	254	255	256	257	258	259	260	261	262	263	264	265	266	267	268	269	270
271	272	273	274	275	276	277	278	279	280	281	282	283	284	285	286	287	288	289	290							

Information on Advertisement No.

301	302	303	304	305	306	307	308	309	310	311	312	313	314	315	316	317	318	319	320	321	322	323	324	325	326	327
328	329	330	331	332	333	334	335	336	337	338	339	340	341	342	343	344	345	346	347	348	349	350	351	352	353	354
355	356	357	358	359	360	361	362	363	364	365	366	367	368	369	370	371	372	373	374	375	376	377	378	379	380	381
382	383	384	385	386	387	388	389	390	391	392	393	394	395	396	397	398	399	400	401	402	403	404	405	406	407	408
409	410	411	412	413	414	415	416	417	418	419	420	421	422	423	424	425	426	427	428	429	430	431	432	433	434	435
436	437	438	439	440	441	442	443	444	445	446	447	448	449	450	451	452	453	454	455	456	457	458	459	460	461	462
463	464	465	466	467	468	469	470	471	472	473	474	475	476	477	478	479	480	481	482	483	484	485	486	487	488	489
490	491	492	493	494	495	496	497	498	499	500	501	502	503	504	505	506	507	508	509	510	511	512	513	514	515	516
517	518	519	520	521	522	523	524	525	526	527	528	529	530	531	532	533	534	535	536	537	538	539	540	541	542	543
544	545	546	547	548	549	550	551	552	553	554	555	556	557	558	559	560	561	562	563	564	565	566	567	568	569	570
571	572	573	574	575	576	577	578	579	580	581	582	583	584	585	586	587	588	589	590							

Students and foreign subscribers (other than Canadian), please request literature directly from manufacturers.

This card not good after March 1.

Aluminum Pipe. Aluminum Co. of America, 18 pp, illus. Aluminum pipe characteristics and advantages for each of its major fields of application. (19)

Casting Resins. Aries Laboratories, Inc., 14 pp. Data given on Aritemp potting and casting resins for high and low temperature electrical and other applications. (20)

Tubes. Tubular Products Div., The Babcock & Wilcox Co., 8 pp, illus, No. TB-329 B. Seamless and welded heat exchanger and condenser tubes made of stainless, alloy and carbon steels. (21)

Plastics and Resins. Bakelite Co., 12 pp, illus. Condensed reference file of Bakelite plastics and resins presents the latest information on properties and uses. (22)

Chains. The Bead Chain Mfg. Co., 12 pp, illus. Bead chain characteristics and applications are described. (23)

Molds. Morris Bean & Co., 4 pp, illus. Describes Antioch process for producing castings that meet wave guide specifications in all bands. (24)

Shell Molding. Beardsley & Piper Div., Peribone Mulliken Corp. Catalog on shell molding and shell sand preparation. (25)

Beryllium. The Beryllium Corp., 20 pp, illus. Product directory of specifications, processing data, applications, and facilities. (26)

Black Light. Black Light Corp. of America, 65 pp, illus. Long wave ultra-violet light for display, industrial inspection, flaw detection, etc. Case histories plus data on research in this field. (91)

Porous Media. Refractories Div., The Carborundum Co., 55 pp, illus. Data on Aloxite aluminum oxide porous media are given for various applications in equipment. (27)

Data Chart. Cerro de Pasco Corp., illus. Wall chart of physical properties and applications of company alloys. (28)

Chromizing Steels. Chromalloy Corp. of New York, 4 pp, illus. Describes process for increasing heat, wear and corrosion resistance of steel by diffusing chromium into the surface. (29)

Molybdenum Applications. Climax Molybdenum Co., 28 pp, illus. Survey of new industrial applications resulting from present molybdenum research. (30)

Hardsurfacing Alloys. Coast Metals, Inc., 6 pp. Describes alloy filled tubes in coils for automatic welding or cut to length for manual application. (31)

Brush Plating. Dalic Metachemical Ltd., 4 pp, illus. Presents advantages of brush plating with the Dalic process. (32)

Industrial Cork. Dodge Cork Co., Inc., 4 pp., illus, No. S-56. Discusses properties of natural and composition cork with specifications and properties. (33)

Forging Guide. Drop Forging Association, 6 pp, illus. Management guide to the use of forgings. (34)

Neoprene Notebook. Elastomer Div., E. I. du Pont de Nemours & Co., Inc., 8 pp, illus, No. 66. Reports developments and illustrates uses of neoprene. (35)

Belt Grinding. Engelberg Huller Co., 31 pp, illus. Case histories on how abrasive belt grinding increased production. (36)

Castability. Engineered Precision Casting Co., 24 pp. Booklet on effect of castability on alloy selection for the investment casting process. (37)

Weldments. The Enterprise Co., 6 pp, illus, No. 601. Advantages of weldments in cutting costs, improving appearance, and saving weight. (38)

Bonded Bi-Metallics. Fairchild Engine & Airplane Corp., 4 pp, illus. News of Al-Fin process and its application to a variety of fields. (39)

Laminated Plastics. The Formica Co., 8 pp, illus. Outlines plastics service and facilities of company. (40)

Ceramics. Frenchtown Porcelain Co., 7 pp, illus, No. 955. Quality control and interior production methods are pictured and a properties chart is included. (41)

Resins. Furane Plastics Inc., 3 pp. Instruction sheets on epoxy resins, their properties and uses. (42)

Plastic Covered Tape. The Garrison Co. Technical data sheet on MET-L-TAPE, a plastic jacketed steel strap. (43)

Plastics Design. Plastics Dept., General Electric Co., illus. Two booklets, "The Plastics Story" and "Fabricated Silicone Rubber Parts", describe case histories and latest applications. (44)

Polyamide Resins. Chemical Div., General Mills, Inc., 16 pp, illus. General information on Versamids and specific data on each of the eight types marketed. (45)

Packings. Greene, Tweed & Co., 16 pp, illus. Lists Palmetto self lubricating packings together with uses and performance data. (46)

Injection Molded Plastic. Gries Reproducer Corp., 4 pp, illus. Illustrates how design engineers can solve planning and production problems with tiny thermoplastic parts. (47)

Brazing. Handy & Harman, 4 pp, illus, No. 17. Instructions for brazing fittings to pipe and tubing with low temperature silver alloy. (48)

Corrosion Control. The Harco Corp., 12 pp, illus. Technical brochure on cathodic protection systems for corrosion control. (49)

Construction Materials. Haveg Corp., 32 pp, illus. Features materials of construction and evaluates equipment molded from polyvinyl chloride, epoxy glass, and polyester glass. (50)

Radiography. High Voltage Engineering Corp., 25 pp, illus. Treats of the importance of radiography as an inspection and quality control tool. Case studies are included. (51)

Precision Springs. Spring Div., Hunter Spring Co. Selected data sheets dealing with basic considerations in the design of precision springs. (52)

Electric Furnaces. Holcroft & Co., 4 pp, illus. General information on electric heating and various heat treat furnaces. (53)

Salt Baths. E. F. Houghton & Co., 32 pp, illus. Tabulates data and gives physical properties and uses of various types of salt baths. (54)

Tube Fittings. Imperial Brass Mfg. Co., 4 pp, illus. Tube fittings for use with stainless steel, nylon, polyethylene, aluminum, copper, and other tubing. (55)

Centrifugal Castings. Janney Cylinder Co., 8 pp, illus. Advantages offered by centrifugal castings and description of quality control techniques. (56)

Plastic Tape. Johns-Manville Sales Corp., 6 pp, illus. Gives data and applications of Dutch brand vinyl color tape. (57)

Aluminum Conductors. Kaiser Aluminum & Chemical Corp., 20 pp, illus. Discusses various types and sizes of triplex and tabulates cost comparisons and efficiencies. (58)

Moldings and Panels. Keller Products, Inc., 21 pp, illus. Products for the building industry are described and data presented. (59)

Oils and Waxes. M. W. Kellogg Co., 16 pp, illus. Describes series of polymer products based on polychlorotrifluoroethylene molecule for oils, waxes, and greases. (60)

Powder Metallurgy. Keystone Carbon Co., 18 pp, illus. Summary of the powder metallurgy process with compositions of a number of production materials. (61)

Steel Bars. La Salle Steel Co., 32 pp, illus, No. 16. Data on residual stresses in cold-finished steel bars and their effect on manufactured parts. (62)

Inspection. Magnaflux Corp., 8 pp, illus. Various uses for nondestructive testing and its role as a production tool. (63)

Precision Cast Irons. McNally Pittsburg Foundries, Inc., 20 pp, illus. Specifications for six classes of metallurgically controlled irons are itemized. (64)

Sprayed Metals. Metallizing Engineering Co., Inc., 6 pp, illus, No. 120. Illustrates a wide range of applications of metallizing, sprayed metal, in the production of electrical and electronic equipment. (65)

Oven Facts. Michigan Oven Co., 19 pp, illus, No. 555. Handbook giving important considerations in the selection of process heating equipment. (66)

Neoprene Coatings. Protective Coatings Div., Metalweld, Inc., 2 pp. Outlines protective qualities of Neoprene in applications affected by various conditions. (67)

Embossing. Modern Engraving & Machine Co., 6 pp, illus. Describes high speed embossing equipment for metals. (68)

Copper Alloys in Rod Form. Mueller Brass Co., 28 pp, illus. Engineering data on copper base alloys are given, together with description of new company facilities. (69)

NSMPA 1955-56 Buying Directory. National Screw Machine Products Assn., 74 pp. Lists more than 270 firms alphabetically and geographically as well as the conditions of sale and manufacturing practices for screw machine products. (70)

Plastics Pipe. National Tube Div., U.S. Steel Corp., 28 pp, illus, No. 24. Data presented on unplasticized rigid polyvinyl chloride pipe both normal and high impact types. Describes installation techniques. (71)

Phosphate Coating. Neilson Chemical Co., 4 pp, illus. Process for cleaning and phosphating metal surfaces for painting. (72)

Modern Testing. Tinius Olsen Testing Machine Co., 25 pp, illus. Anniversary issue traces major advances in design of testing and balancing equipment from 1880. (73)

Plastics Reinforcement. Plastics Reinforcement Div.. Owens-Corning Fiberglas Corp., 27 pp, illus. Illustrates applications for reinforced plastics and gives data on physical properties of typical molding compounds. (74)

Corrosion Prevention. Parker Rust Proof Co., 12 pp, illus. Properties and uses of Bonderite, a corrosion resisting paint base for iron, steel, cadmium, zinc, and aluminum. (75)

Formed Wire Products. Peerless Wire Goods Co., Inc., 8 pp, illus. Facilities and services of company described in manufacture of wire products. (76)

Forgings. Pittsburgh Forgings Co., 4 pp, illus. Pictures types of forgings made for railroad freight cars. (77)

Investment Casting. Precision Metalsmiths, Inc., 12 pp. illus. Answers questions on precision castings and contains a comprehensive table of investment casting alloys and their properties. (78)

Small Tubing. Precision Tube Co., 4 pp, illus. Applications of small tubing. 7/8-in. o.d. to 0.010-in. o.d., for all industry. (79)

Plastics Fabrication. Regal Plastic Co., 4 pp, illus. Custom contract service from designing and engineering to finished part, assembly or product—using plastic sheets, rods, tubes, reinforced fiberglass. Includes special bulletin on cases. (92)

Fabricated Alloys. Rolock Inc., 32 pp, illus. Comprehensive catalog on heat and corrosion resistant fabricated alloy products. (80)

Formable PVC. Plastics Div., Seiberling Rubber Co., 3 pp. Describes Seilon FHI, a high impact PVC combining strength and good forming properties. Includes data sheet. (81)

Lock Washers. Shakeproof Div., Illinois Tool Works, 31 pp, illus. Illustrates a variety of lock washers for many applications. (82)

Plastic Molding. Sinko Mfg. & Tool Co., 4 pp, illus. Facilities for producing molded parts and products, including automatic injection molding machines with capacities ranging from 4 to 60 oz. (83)

Ultrasonic Testing. Sperry Products, Inc., 8 pp, illus. Describes ultrasonic reflectoscope for nondestructive testing of metals and materials for surface and internal defects. (84)

Spot Welding. The Taylor-Winfield Corp., 4 pp, illus. Equipment for roll spot welding illustrated and described. (85)

Wire Construction. E. H. Titchener & Co., 11 pp, illus. Study of 36 case histories shows how wire in product design cuts costs. (86)

Precision Impellers. Universal Castings Co., 4 pp, illus. Technique of pouring at low temperatures and applied vacuum described for casting precision impellers. (87)

Sintered Metal Parts. U. S. Graphite Co., 40 pp, illus. Features of Gramix parts and bearings compacted from metal powders under pressures up to 70,000 psi and sintered in high temperature furnaces. (88)

Aluminum Alloy Chart. U. S. Reduction Co. Practical and handy sliding chart of USCO aluminum alloys giving casting and physical data. (89)

Nylon Screws. Weckesser Co., 3 pp, illus. Describes black nylon screws and nuts, use in design problems, and price list for various types. (90)

Wire Parts, Small Metal Stampings. Art Wire & Stamping Co., 4 pp, ill. Profusely illustrates a variety of wire parts and small metal stampings produced in both ferrous and nonferrous metals. (100)

Stainles Steel Tubing. J. Bishop & Co., 7 pp. Mechanical, capillary, hypodermic, and small tubular specialties in stainless steel, nickel, and nickel alloys. Table of comparative properties of various alloys. (101)

Heating Rate of Steel. Bloom Engineering Co., 30 pp, illus. Reprint of AISI paper, "The Rate of Heat Absorption of Steel", detailing a simplified method to calculate steel heating rates and center temperatures. (102)

Welded Steel Tubing. Brainard Steel Co., Tubing Div., 8 pp, illus. Shows facilities for manufacturing welded steel tubing, its applications, fabrications, specifications. (103)

Duplex Tubing. Bridgeport Brass Co., 14 pp, illus, No. 1954. Explains the use of Duplex tubes for heat exchangers and condensers in which internal and external corrosion conditions differ. (104)

Wire Cloth Belts. Cambridge Wire Cloth Co., 140 pp, ill. Revised catalog giving data on wire mesh conveyor belts, including applications and specifications. (105)

Stainless Steel Heads. G. O. Carlson, Inc. Various lists of typical uses and dies available. Price lists included. (106)

Specialty Steels. Carpenter Steel Co., 32 pp, illus. A guide to tool and die steels, stainless steels; silicon and nickel alloys; special purpose alloy steels; valve, heat resisting, and super alloy steels; tubing and pipe; and fine wire specialties. (107)

Circular Steel Shapes. Commercial Shearing & Stamping Co., 24 pp, illus, No. P-3. Covers company's range of cold formed circular steel blanks, flanged and dished shapes, produced from stocked dies. (108)

Stainless Steels. Cooper Alloy Corp., 8 pp, No. 55. Engineering data for stainless steels, comparison of material casting factors. mechanical properties of cast stainless steel, and extensive corrosion data. (109)

Stainless Steel Fabrication. Crucible Steel Co. of America, 160 pp. Fabricator's handbook for Rezistal stainless steels. Forming, machining, cutting, joining, heat treating, pickling, finishing and reference data. (110)

Stainless Steel. Firth Sterling. Inc., 2 pp, No. 25-150. Application data for corrosion and wear resistance. (111)

Flexible Tubing. Flexible Tubing Corp., 8 pp, ill, No. C2-4. Flexible tubing for pneumatic material handling, ventilation and industrial ducting. (112)

Pearlitic Malleable Castings. Central Foundry Div., General Motors Corp., 70 pp, illus. Provides full engineering data on Armasteel castings, plus machining and processing information. Available by request on company letterhead to Central Foundry Div., General Motors Corp., Saginaw, Mich.

Other Available Literature

Irons and Steels • Parts • Forms

Welded Parts. Acme Tank & Welding Div., 4 pp, ill. Shows this plant's facilities for welding complex shapes and discusses advantages of using welded construction by competent welders. (95)

Stainless Steel Powders. Alloy Metal Powders, Inc. Concerns sintering of high temperature alloy powders in the stainless steel group and the availability of such grades. (96)

Shaped Wire. American Chain & Cable Co., Inc., 16 pp, illus, No. DH-1226. How to reduce machining costs with shaped wires produced in high and low carbon steels, low alloy steels, stainless steels and ingot iron. Applications include furniture stripping, oil retaining rings, etc. (97)

Metal Strip. American Silver Co., Inc., 6 pp, ill. Thin gage, close tolerance strip metal for industrial use. Includes a new beryllium-copper thickness tolerance list. (98)

Stainless Fastenings. Anti-Corrosive Metal Products Co., Inc. Catalog giving net prices and actual quantities in stock for stainless steel fastenings. (99)

Sheet Metals. Geuder, Paeshke & Frey Co. Illustrates any completed jobs and gives information on facilities for stamped or drawn metal products. (113)

Gray Iron. Gray Iron Founders' Society, Inc. Data Sheet and 12-pp booklet. Data sheet summarizes gray iron specifications. Booklet contains articles on how and when to use gray iron, and its adaptability for casting. (114)

Stampings. Laminated Shim Co., Stampings Div., 12 pp, ill. Describes facilities for producing good quality stampings to specifications, facts to be considered in ordering stampings and other data. (115)

Constructional Alloy Steel. Lukens Steel Co., 18 pp. Properties and applications of low carbon, quenched and tempered alloy plate steel (T-1), available in thicknesses from ¼ in. to 6 in. (116)

Threaded Stampings. Mohawk Mfg. Co., 2 pp, No. 851. Illustrates variety of products produced by Mohawk's stamping processes, guaranteeing uniform threaded parts with uniformly threaded holes. (117)

Carbon and Alloy Steel Tubing. Ohio Seamless Tube Div., Copperweld Steel Co., 8 pp. Describes four major classifications of carbon and alloy steel tubing; mechanical, pressure, airframe, and aircraft mechanical. Covers both seamless and electric resistance welded tubing, as well as tube fabricating and forging. (118)

Steel Castings. Ohio Steel Foundry Co., 14 pp, illus. Illustrates the many types of castings, including carbon-steel and alloy castings, heat resistant alloy castings and stainless steel castings. (119)

Metal Containers. Pressed Steel Tank Co., 16 pp, ill. Tells how many industries have been helped in quality production at low cost by use of Hackney Metal containers and deep drawn component parts. (120)

Iron Powder. Pyron Corp., 8 pp, No. 1. Technical data sheets on hydrogen reduced and electrolytic iron powders. Sintering data, effect of infiltrants, dimensional stability, strengths, etc., chartered. (121)

Steel Tubing. Sawhill Tubular Products, Inc., 16 pp. Information on grades and size range of company's steel tubing. (122)

Spun Metal Parts. Spincraft, Inc., No. 3. Data book on metal spinning and fabricating gives data on process and help in designing for economical production. (123)

Steel Castings. Steel Founders' Society of America, 4 pp, illus, No. 69. Describes reduced costs and expanded plant capacity through use of steel castings. Also lists characteristics of steel castings. (124)

Powder Metallurgy. F. J. Stokes Machine Co., 36 pp, illus. Clear, concise discussion of powder metallurgy including summary of process, applications, mechanical characteristics of powder metal parts, and design considerations. (125)

Clad Metals. Superior Steel Corp., 24 pp, ill. An introduction to clad metals offering a comprehensive survey of the manufacture and application of stainless, copper, brass and other clad steels. (126)

Bi-Metallic Construction. Arthur Tickle Engineering Works, 8 pp, illus. Description of Alumibond process for molecularly bonding aluminum and its alloys to iron and steel and their alloys. (127)

Steels. Timken Roller Bearing Co., Steel & Tube Div., Canton, Ohio. Complete catalog of steels produced by this company. Request on company letterhead direct from Timken.

Leaded Steel and Free-Cutting Brass. Titan Metal Mfg. Co., 48 pp, illus. Machinability of free-cutting brass compared with that of leaded steel. From results of research laboratory tests on two commercial metals and six-month production runs. (128)

Small Precision Metal Parts. Torrington Co., 4 pp, illus. Illustrates the various small precision metal parts custom-made by the Specialties Div. of Torrington. (129)

Stainless and High Alloy Tubing. Trent Tube Co., 48 pp, illus. Classifies types of tubing, giving typical applications, physical, chemical and electrical properties for each. Information on welding, bending and installation techniques. (130)

Alloy Steel Castings. Unitcast Corp., 2 pp. Specifications, characteristics and uses of T-loy 42, alloy steel castings. (131)

Prealloyed Steel Powder. Vanadium-Alloys Steel Co., 4 pp, illus. Describes alloy steel powder with high hardenability not obtainable with iron-carbon mixes. Typical applications include gears, bushings and piston rings. (132)

Ferro-Alloys and Metals. Vanadium Corp. of America, 24 pp, ill. "The Vancoram Review" presents technical articles on applications and developments in ferro metallurgy especially concerned with vanadium alloys. (133)

Stampings. WLS Stamping Co., 4 pp, ill. Describes high-speed, low-cost stamping process using "speed tooling" method. (134)

Stainless Steel Sheet and Strip. Washington Steel Corp., 4 pp. Includes types, uses, physical properties and specifications of MicoRold stainless steel sheet and strip. (135)

Stainless Steel Castings. Waukesha Foundry Co., 4 pp, ill, No. WF-5. Shows facilities of this company for producing any hard-to-shape type of stainless steel castings. (136)

Finned Tubing. Wolverine Tube Co., 1 p. Sample of Wolverine Trufin integral-finned tube for heat transfer equipment and other uses. (137)

Metal Powder Parts. Powdered Metal Products Div., Yale & Towne Mfg. Co., 6 pp, ill, No. 352. Shows a variety of ferrous and nonferrous metal powder parts fabricated by this company. (138)

Mechanical Tubing. Youngstown Sheet & Tube Co., 4 pp, ill. Features size and wall thickness of a complete line of Yoloy electric weld mechanical tubing. (139)

To obtain literature appearing on these pages, please refer to easy-to-use reply card on pages 67 and 68

Nonferrous Metals • Parts • Forms

Aluminum Bronze. Alcaloy, Inc., 36 pp, illus. Application of aluminum bronze for non-sparking chains, fittings and tools. (144)

Brazing Alloys. Alloy Ring Service, Inc., 4 pp. Brazing alloys in the form of rings or fabrications. (145)

Machining Copper. American Brass Co., 32 pp, illus, No. B-3. Suggestions for machining copper, brass, bronze and nickel silver including tool rakes, clearances, cutting speeds and feeds. Tables give physical properties, constants and specifications of Anaconda metals and alloys. (146)

Engineering Bronzes. American Crucible Products Co., 12 pp, ill. Includes complete data on facilities, technical information, case histories and applications of Promet bronzes. (147)

Pre-Finished Metals. American Nickeloid Co., 24 pp, illus. Fabrication techniques, uses and properties of prefinished metals are described, along with case histories of applications in various manufacturing fields. (148)

Cast Aluminum. American Smelting & Refining Co., 20 pp, ill, No. 165. "Practical Help in the Casting of Aluminum Alloys". Deals with the effects of moisture, shrinkage, dross, pouring temperature and test bars. (149)

Precision Investment Castings. Arwood Precision Casting Corp., 16 pp, ill. Informative article on precision investment castings. Includes table of ferrous and nonferrous alloys recommended as most adaptable for this process. (150)

Precision Castings. Atlantic Casting & Engineering Corp., 12 pp, illus. How to obtain nonferrous castings cast to ordinary machining tolerances. Describes process and gives alloy specifications. (151)

Investment Castings. Austenal Laboratories, Inc., 12 pp, illus. Describes Microcast process and charts representative properties of investment cast alloys. (152)

Magnesium and Aluminum Alloy Castings. Bendix Foundries, 4 pp. Facilities for sand, die, shell, plaster and permanent mold castings of magnesium or aluminum. (153)

Bimetals. W. M. Chace Co., 36 pp, ill. Describes and explains 22 uses of bimetals as actuating elements in temperature responsive devices. (154)

Machining Titanium. Cincinnati Milling Machine Co., 16 pp, ill, No. M-1866. Discusses machining characteristics with emphasis on chip formation. (155)

Static and Centrifugal Castings. Duraloy Co., 16 pp, illus, No. 3354-G. Describes

Manufacturers' Literature

facilities for producing high alloy static and centrifugal castings. Engineering data on castings for heat, corrosion and abrasion resistance. (156)

Magnesium and Aluminum Castings. Eclipse-Pioneer Div. Foundries. "Book of Facts" shows company's facilities for custom-making aluminum and magnesium castings. (157)

High Density Metal. Fansteel Metallurgical Corp., 16 pp, illus. Properties and uses of Fansteel 77 Metal, machinable tungsten-copper-nickel alloy, 50% heavier than lead, used for counterweights, flywheels, vibration damping, and radiation shielding devices. (158)

Short Run Stamping. Federal Tool & Mfg. Co., 4 pp, illus. Describes company's facilities for short run stamping and phenolic die stamping (159)

Aluminum Designation System. Peter A. Frasse & Co., Inc. Conversion chart for new designation system with explanation of conversion procedure. (160)

Investment Castings. Gray-Syracuse, Inc., 4 pp, ill. Parts of precision cast brass, bronze, beryllium copper and steel. (161)

High Temperature Alloys. Haynes Stellite Div. "Haynes Alloys for High Temperature Service" provides detailed tables and charts on their properties and heat treatment. (162)

Laminated Metals. Improved Seamless Wire Co., Inc., 6 pp, ill. Describes the importance and applications of laminated metals to modern industry. (163)

Metal Tubing. International Metal Hose Co., 4 pp, ill. Applications, specifications and list prices of flexible metal hose. (164)

Bronze Bars. Johnson Bronze Co., 4 pp, ill. Completely machined 13-in. bars for bearings, bushings, thrust plates and washers. Other applications and machining data listed. (165)

Lithium Metals and Compounds. Lithium Corp. of America. Data sheets on properties and uses of lithium metal and organic and inorganic lithium compounds for metal treatment, ceramic modifications, welding, etc. (166)

Alloy Metals. Littleford Bros., Inc., 4 pp, ill. Facilities for fabricating large assemblies and small parts for various metal alloys. (167)

Tin. The Malayan Tin Bureau. "Tin News," a monthly publication of the Malayan Tin Bureau, reviews market situation, tin uses and political developments affecting the supply of tin. (168)

Die Castings. Monarch Aluminum Mfg. Co. File data on aluminum and zinc die castings and aluminum mold castings showing applications, advantages and this company's facilities for making them. (169)

Powdered Metal Bearings. National Molded Products, Inc., 60 pp, ill. Describes process, design factors and specifications for cylindrical and flanged bearings. Stock list. (170)

Precision Investment Casting. National Precision Casting Corp., 4 pp, illus. Case histories of savings effected by using investment casting for small or intricate parts. (171)

Brass Powder Parts. New Jersey Zinc Co., 4 pp, illus. Describes applications of brass powder parts in self-developing cameras, rotors, drive bars. (172)

Spun Shapes. Phoenix Products Co., Metal Spinning Div., 4 pp, ill. Describes Phoenixspun methods for spinning spherical and extra deep-drawn contours. (173)

Die Castings. Precision Castings Co., Inc., 24 pp, ill. Describes company's integrated facilities for quantity production of aluminum, magnesium and zinc die castings. (174)

Aluminum Extrusions. Precision Extrusions, 12 pp, ill. Describes aluminum extrusion process with tables of physical properties and recommended applications. (175)

Machining of Titanium. Rem-Cru Titanium, Inc., 8 pp, illus, Vol. 1, No. 1. Discusses titanium machining practices and procedures recommended by customers having titanium application experience. (176)

Aluminum Mill Products. Reynolds Metals Co., 16 pp, illus. Contains wrought aluminum selection guide outlining general properties of various aluminum mill products, and lists their applications. A casting alloy selection guide is also included. (177)

Textured Metal. Rigidized Metals Corp., 6 pp, ill. Describes briefly forming techniques and methods of joining textured sheet which is supplied in a wide range of metal alloys and patterns. (93)

Zinc Die Casting. St. Joseph Lead Co., 24 pp, ill. Discusses role of zinc as a base metal for die casting alloys and lists the variety of commercial finishes for zinc base die castings. (178)

Centrifugal Castings. Sandusky Foundry & Machine Co., 6 pp, ill. Specification chart for ferrous and nonferrous alloys for centrifugal castings. (179)

Precision Investment Casting. Alexander Saunders & Co., 14 pp, ill. Discussion of advantages of this process in comparison with conventional methods of production, techniques, equipment and supplies needed. (180)

Aluminum Strip. Scovill Mfg. Co., 20 pp, ill. Physical characteristics, temperature designations, weights and fabricating data for aluminum alloy strip. (181)

Aluminum Castings. Solon Foundry, Inc., 4 pp, ill. Description of company's plant and facilities for producing aluminum castings. (182)

Light Metal Castings. Thompson Products, Inc., 8 pp, ill. Describes a complete line of precision die castings for various industrial uses. (183)

To obtain literature appearing on these pages, please refer to easy-to-use reply card on pages 67 and 68

Rigidized Metal Bonded Plywood. United States Plywood Corp., 8 pp, ill. Gives special features, advantages and wide variety of uses for Armoply, sheet metal bonded plywood. (184)

Aluminum Extrusions. Valley Metal Products Co., 4 pp, No. 015. Standard forms of aluminum extrusions. (185)

Pipe and Tubing. The Wallingford Steel Co., 8 pp, ill. Stainless, carbon and alloy steel tubing for ornamental, mechanical, pressure, sanitary and aircraft use in size range from ¼-in. to 3-in. O.D. (186)

Nonferrous Castings. Wellman Bronze & Aluminum Co., 16 pp, ill, No. 50. Includes facilities of this company for producing a variety of nonferrous castings and wood or metal patterns. (187)

Light Metal Forgings. Wyman-Gordon Products Corp., 4 pp, ill. Announces the availability of large-size light alloy forgings, particularly those of magnesium and 75-S aluminum. (188)

Nonmetallic Materials • Parts • Forms

Silione Rubber. Acushnet Process Co., 8 pp, ill, No. B. Describes method of custom-compounding silicone rubber. Gives property ratings, molding techniques, mold design and design specifications. (193)

Thermosetting Plastics. American Cyanamid Co. Thirty success stories show outstanding sales advantages of using Cyanamid plastics, which are hard-wearing, hard-surfaced and hard-to-break. (194)

Felt Samples. American Felt Co., 8 pp. SAE felt standards and specifications, with samples exhibiting 16 different grades. (195)

Flexible Tubing. American Hard Rubber Co., 4 pp, ill, No. 66-D. Physical properties, chemical resistance, standard sizes and characteristics of transparent plastic tubing. (196)

Extruded Plastics. Anchor Plastics Co. 12 pp, ill. Applications of thermoplastic rods, tubes and shapes. Summary of properties of plastics materials with usage table. (197)

Fiberglass Ducts. The Arrowhead Rubber Co., 16 pp, ill. Information on Airtron fiberglass ducts, sleeves and couplings; describes five basic types; and shows typical applications. (198)

Corrosion-Proof Structural Plastic. Atlas Mineral Products Co., 6 pp, ill, No. 9-1. Engineering data on Ampcoflex, an unplasticized, rigid polyvinyl chloride for use in corrosion-proof construction. (94)

Coated Abrasives. Behr-Manning Corp., 60 pp, illus. Compilation of technical papers on coated abrasive grinding and polishing techniques. Covers coated abrasives theory and practice, contour polishing and grinding, part sizing and deburring, etc. (199)

Woven Glass Roving. Bigelow-Sanford Carpet Co., Inc., 2 pp. Describes mechanically bonded glass fabric used in reinforced plastics, and lists advantages. (200)

Molding Compounds, Resins and Cements. The Borden Co., Chemical Div., 8 pp, ill, No. 10M. General properties and uses of Durite specially prepared phenolic molding compounds, resins and cements. (201)

Ceramic Coating. California Metal Enameling Co., 4 pp, ill. Ceramic coatings for metals for high temperature service. Includes sample of ceramic coated 0.001-in. stainless and steel foil. (202)

Polyethylene Sheeting. Celanese Corp. of America, 6 pp, No. NP-13. Physical and chemical properties of polyethylene sheeting for tank linings, molded items, ducts, etc. (203)

Resin-Bonded Laminates for Finishing. The Chemical Corp., 20 pp, ill, No. PD-1R353. Data sheets discuss a variety of tanks, ducts, hoods, stacks and waste pipe for corrosion resistant use. (204)

Plastisol. Chemical Products Corp., 8 pp, ill. Chem-O-Sol plastisol formulation for industrial and consumer products. Instructions for use and several case histories of coated products. (205)

Impact Styrene Sheet. Chicago Molded Products Corp. Describes high-gloss surface finish for impact styrene sheet. Includes applications. (206)

Metallic Abrasives. Cleveland Metal Abrasive Co., 16 pp, illus. Discusses three types of metallic abrasives and selection of abrasion method. (207)

Thermoplastic. Colonial Plastics Mfg. Co., Industrial Div., 16 pp. Technical data on properties, available forms, fabrication and applications of Lucoflex, a rigid polyvinyl chloride. (208)

Extruded Plastic. Conneaut Rubber and Plastics Co., 4 pp, ill, No. CR-53. Die making and production facilities of rubber and plastic extrusions. (209)

Industrial Glassware. Corning Glass Works, 8 pp, illus, No. B-91. Describes silica glass with thermal shock resistance and chemical stability. Applications include stove top units, heat lamp bulbs and laboratory equipment. (210)

Custom Laminations and Extrusions. Dobeckmun Co., 4 pp, illus. Describes facilities for custom laminations of customers' materials or specialized conversion of films, foils and papers for applications such as pipe wraps, duct facing, polyethylene coated cloth, etc. (211)

Honeycomb Material. Aircomb Section, Douglas Aircraft Co., Inc., Development of Aircomb, a honeycomb structure of Kraft paper impregnated with a phenolic resin. Precut in any thickness from 1/16 to 5 in., it is said to be 16 times as rigid as an equal weight of steel, durable, fire-resistant, pest-resistant, has excellent insulation, soundproofing properties. (212)

Degreasing Solvent. Dow Chemical Co., 6-page illus folder. Describes degreasing solvent "Chlorothene" for cold-cleaning, dip-cleaning and bucket cleaning operations. (140)

Black Oxide Finish. Du-Lite Chemical Corp. Information on Du-Lite finishes for any steel blackening problem. Also gives information on Du-Lite cleaner, strippers, burnishing compounds, etc. (213)

Polyester Film. E. I. du Pont de Nemours & Co., Inc., Film Dept., 22 pp, illus. Discussion of range of applications of Mylar. (141)

Nylon Resin. E. I. du Pont de Nemours & Co., Inc., Polychemicals Div., 54 pp. Describes "Zytel", a nylon resin supplied as molding powder for conversion into wire-coatings, rods and other extruded shapes. Final products have outstanding toughness, abrasion resistance, form stability at high temperatures, and chemical resistance. (214)

Industrial Textile Fibers. E. I. du Pont de Nemours & Co., Inc., Textile Fibers Dept., 20 pp. Consideration of synthetic fibers as industrial materials. Includes rayon, acetate, nylon, orlon, dacron, teflon fibers. (215)

Electroformed Molds. Electromold Corp., 4 pp. Gives details of electroforming process for plastics molds. (216)

Reinforced Wood. Gamble Bros., Inc., 4 pp. Wood coated with high strength thermoplastic gives higher strength wear, and impact resistance. (217)

Silicone Rubber. General Electric Co., 4 pp, No. AD 24 E. Chart for selecting silicone rubber grades for mechanical goods. (218)

Polyvinyl Chloride Resin. General Tire & Rubber Co., Chemical Div. Illustrated folder on polyvinyl chloride resin for calendering, extruding and molding operations. (142)

Precision Parts. General Tire & Rubber Co., Industrial Products Div., 6 pp, ill. Describes company's facilities for producing precision parts in rubber and plastics. (219)

Coated Fabric. Textileather Div., General Tire & Rubber Co., 6 pp, illus. Introduces Nygen Tolex and nylon reinforced coated fabrics. (220)

Hycar Rubber. B. F. Goodrich Chemical Co., 22 pp, ill. Complete analysis of properties and uses of Goodrich oil and solvent resistant rubber. (221)

Latices. Chemical Div., Goodyear Tire & Rubber Co., Inc., 4 pp. Properties and uses of nitrile, vinyl, and styrene latices. (222)

Insulation Hardboard. Great American Industries, Inc., Rubatex Div., 16 pp, ill. Design data for building insulation applications of Rubatex Hardboard (expanded synthetic rubber compound). (223)

Plastics. Heil Process Equipment Corp., 4 pp, ill, Vol. 4, No. 1. Suggests applications for Rigidon, a glass-reinforced plastic; Rigidin, a rigid vinyl plastic; and Rigidene, a polyethylene plastic. (224)

Adhesives and Coatings. Houghton Laboratories, Inc., 96 pp. Bound volume of technical bulletins and price lists covering adhesives, coatings and plastics materials. (225)

Rigid Polyvinyl Chlorides. Kaykor Industries, Inc., Div. of Kaye-Tex Mfg. Corp., 6 pp. Chemical and physical properties of Vyflex rigid polyvinyl chloride plates and sheets. (226)

Refractory Porcelain. McDanel Refractory Porcelain Co., 36 pp, ill. Catalog of high temperature porcelain products with physical, mechanical and electrical properties. (143)

Glass Reinforced Plastics. Molded Fiberglass Co., 6 pp, illus. Facilities for producing glass fiber reinforced plastics molding. (227)

Printed Circuits. National Vulcanized Fibre Co., 12 pp, illus. Discusses methods of producing printed circuits. Detailed specifications on grades and properties of copper-clad phenolic laminated plastic. (228)

Plastic Resins and Compounds. Naugatuck Chemical Div., U. S. Rubber Co., 8 pp, ill. Vinyl, polyester and elastomeric resins and compounds, applications, properties and processing. (229)

Carbon Parts. Ohio Carbon Co., 4 pp, illus. Gives thermal, mechanical and electro-mechanical properties of company's carbon parts. (189)

Metal Laminate. O'Sullivan Rubber Co., 4 pp. Describes Sulvyne-Clad metal laminate, a vinyl plastic sheeting bonded to metal to form a pre-finished material. Includes physical and chemical properties of laminate. (230)

Molded Rubber. Parker Rubber Products Div., Parker Appliance Co., 4 pp, ill, No. 5201A1. Custom molding facilities for rubber parts. (231)

Fiber Glass. Pittsburgh Plate Glass Co., 4 pp, ill. Lists advantages of using glass fiber for sound and heat insulation applications. (232)

Industrial Tape. Polyken Products, 4 pp. Sixteen pressure-sensitive tape samples with accompanying specifications and properties. Explains basic industrial tape applications. (190)

Carbon Graphite. Pure Carbon Co., Inc., 32 pp, ill, No. 52. Technical data on description, properties, applications and specifications of Purebon carbon graphite. (233)

Polyester Resins. Reichhold Chemicals, Inc. Brochure includes 11 technical bulletins of 2 to 6 pages each describing the Polylite line of liquid thermosetting polyester resins. The bulletins cover molding characteristics and physical properties of 10 resins of various heat and light resistant grades, suitable for use in glass fiber reinforced applications. (235)

Chemically Resistant Products. Resistoflex Corp., 6 pp, illus. Folder on chemically resistant industrial hose and plastics. (236)

Molded Rubber Produts. Roberts Toledo Rubber Co., 16 pp, illus. Describes company's facilities for producing molded rubber parts. (237)

Plastic Molding. Romar Plastics, Inc., 4 pp, illus. Describes company's facilities for all stages of plastic molding. (238)

Rubber. Roth Rubber Co. Kit containing actual rubber samples with hardness from 5 to 100 Durometer. Accompanied by ASTM specifications and list of uses for each sample. Offer limited to engineers and rubber buyers only. Please request Roth Rubber Sampler No. MM3 on company letter-

Manufacturers' Literature

head from Roth Rubber Co., 1860 So. 54 Ave., Chicago, Ill.

Signaling and Recording Attachment. Sperry Products, Inc., 2 pp, illus, No. 50-130. Gives applications and description of semi-automatic testing with Type UR Reflectoscopes. (191)

Rubber Parts. Stillman Rubber Co., 24 pp, ill. Facilities and products of custom molding company. (239)

Reinforced Plastics. Strick Plastics Corp., 4 pp, illus. Describes reinforced polyester laminate with good thermal, electrical, chemical and mechanical properties. Typical applications given. (240)

Laminated Plastics. Synthane Corp., 4 pp, ill. Military government and other specifications of Synthane laminated plastics sheets, tubes and rods. (192)

Rubber Engineering Data. Tyer Rubber Co. Illustrates company's molded and extruded rubber products and provides technical specifications and relative properties of natural rubber, Buna S, Buna N, neoprene, butyl, thiokol and silicone. (241)

Aluminum Wire. U. S. Rubber Co., 30 pp, tables. A handbook describing the uses and properties of aluminum for power and lighting wire. (242)

Industrial Fibers and Textiles. Wellington Sears Co., 26 pp, illus. Properties of industrial textile fibers, including cotton, rayon, acetate, nylon, acrylic, polyester, glass, vinyl and protein. Defines yarn designations, basic weaves and variations as used in fabrics. How fabrics are selected for use with rubber; as coated fabrics; in laminated plastics; for filtration purposes; and other applications. (243)

Synthetic Rubber Sheet and Roll Goods. Acadia Div., Western Felt Works, 2 pp, samples. Ten samples clipped to chart of physical specifications. Durometer, tensile and elongation characteristics. (244)

Laminated Plastics. Westinghouse Electric Corp., 50 pp. Catalog on industrial Micarta covering all grades and forms in which Micarta is supplied, and the chemical, mechanical and electrical properties of each. Machining data gives fabrication information. (234)

Annealed Polystyrene. Westlake Plastics Co., 2 pp, No. 55-1. Describes company's process of annealing polystyrene molded and extruded parts to improve properties. (245)

Sealing Design. Franklin C. Wolfe Co., Inc., 4 pp, ill. Describes facilities and products for sealing bolts, studs, rivets, flanges, etc. (246)

Finishes • Cleaning and Finishing

Sodium Nitrite. Allied Chemical & Dye Corp., Solvay Process Div., No. SP-23A. Describes uses of sodium nitrite for protecting metal surfaces against rust or corrosion. (251)

Hot Dip Galvanized Coatings. American Hot Dip Galvanizer's Association Inc., 16 pp, ill. Description of hot dip galvanizing process in industrial and consumer item applications. (252)

Blast Cleaning. Baldwin-Hill Co., 4 pp, illus. Describes mineral shot for blast cleaning that prepares metal surface in one air blast application. (253)

Spray Painting. Conforming Matrix Corp., 5 pp, ill. Gives description, uses, and advantages of this firm's spraying masks, mask washing machine, and spray painting equipment. (254)

High Vacuum Equipment. Consolidated Vacuum Corp. Price list of high vacuum equipment and accessories. (255)

Aluminum Finishing. Diversey Corp., 4 pp. Lists company's cleaning and finishing equipment for aluminum. (256)

Synthetic Elastomers. Fabrics Div., E. I. du Pont de Nemours & Co., 7 pp, illus. Properties and uses of various grades of Fairprene elastic composition for sheet stock, coated fabrics, and adhesives. (257)

Air Dry Lubricant. Electrofilm Corp., 4 pp, ill. Complete data on Lubro-bond, a dry film lubricating compound specifically designed to meet the anti-friction requirements of industry. Prices included. (258)

Metallographic Polishing with Diamond. Elgin National Watch Co., 8 pp, illus. Booklet No. 2 Diamond Series. Information guide for industrial diamond users. (259)

Spray Painting Equipment. Finish Engineering Co., Inc., 16 pp, illus. Describes pressure formed spray painting masks and auxiliary equipment. Price list included. (260)

Solution Coating Resin. Firestone Plastics Co.. 8 pp, No. 13. Properties and uses of Exon 450 vinyl chloride copolymer resin for solution coatings, either permanent or strippable. (261)

Bright Nickel Plating. Harshaw Chemical Co., 4 pp, illus. Describes advantages of Nubrite bright nickel plating process. (262)

Barrel Finishing. Lord Chemical Corp., 32 pp, ill. Introductory bulletin describes various compounds for precision barrel finishing. (263)

Chemical Resistant Coatings. McDougall-Butler Co., Inc., 4 pp, illus. Describes chemical resistant coating used without primer on metal and wood surfaces. (264)

Silicone-Base Finish. Midland Industrial Finishes Co. Brochure describes silicone-base finish. said to resist heat of 500 F without discoloration. (265)

Metal Cleaner. Niagara Alkali Co. Pamphlet gives properties of Nialk Trichlorethylene, high quality metal-cleaning and degreasing agent. (266)

Iron Phosphate Coatings for Steel. Oakite Products, Inc., 12 pp, illus. How to improve paint adhesion and prevent corrosion on steel with iron phosphate coatings. (267)

To obtain literature appearing on these pages, please refer to easy-to-use reply card on pages 67 and 68

Blast Cleaning and Dust Control. Pangborn Corp., 16 pp, ill, No. 226. Describes various models of "Continuous-Flo Rotoblast" barrels available for production line blast cleaning to reduce cleaning costs. (268)

Paint Spray. Ransburg Electrocoating Corp., 16 pp, ill. Description of electrostatic spray paint process for automatic industrial applications. (269)

Crack-free Chromium. United Chromium Div., Metal & Thermit Corp., 4 pp, illus, No. CFC-1. Outlines properties of finishes obtainable with the new Unichrome, crack-free chromium plating process. (270)

Methods and Equipment

Salt Baths. Ajax Electric Co., 4 pp. Abstracts of published technical articles on salt bath processing. (275)

Screw Machine Parts. Allmetal Screw Products Co., Inc., 96 pp, ill., No. 53. Catalog of bolts, nuts, keys, valves and fittings and other screw machine products. Thumb indexed. (276)

Molybdenum Disulfide Lubricant. Alpha Molykote Corp., 4 pp, 103A. Lists 17 types of molybdenum disulfide lubricants for extreme bearing pressure, and gives high temperature applications. Selector chart included. (277)

Heat Treating Equipment. American Gas Furnace Co., 24 pp, illus, No. C-1304. Covers company's line of blow pipes, forges, pot furnaces, brazing and industrial heating machines, etc. Copy may be obtained by writing directly to American Gas Furnace Co., 140 Spring St., Elizabeth, N. J., on company letterhead.

Electrical Insulators. American Lava Corp., 14 pp, No. 546. Catalog of company's available stock of high frequency electrical insulators meeting JAN-1-8 specifications. (278)

Silver Brazing. American Platinum Works, 48 pp, ill. Reference manual on silver brazing discusses low temperature brazing, brazing alloys, design considerations and other topics. (279)

Test Chambers. American Research Co., 4 pp, ill. Describes the basic environmental test chambers produced by this company for testing under a variety of conditions. (280)

Bronze Electrodes. Ampco Metal Inc., 24 pp, ill, No. W17. Describes complete line of products for use with metal-arc, tungsten-arc, carbon-arc, submerged-arc and inert-arc consumable electrode processes. (281)

Bolts, Nuts and Screws. Buffalo Bolt Co., Div. of Buffalo Eclipse Corp., 150 pp, ill, No. 51. Comprehensive guide for purchasing bolts, nuts and screws, includes blueprints, specifications and prices. Write on company letterhead direct to Buffalo Bolt Co., 101 East Ave., No. Tonawanda, N.Y.

Chromium-Molybdenum Electrodes. Champion Rivet Co., 11 pp, plus graphs. New welding electrodes for chromium - molybdenum alloy steels.

Complete welding data including physical properties, chemical analyses of weld deposits, mechanical properties and welding technique analysis. (283)

Forgings. Cleveland Hardware & Forging Co., 38 pp, ill, No. 19A. Catalog of stock industrial and automotive forgings. (284)

Screws with Integral Washer. Continental Screw Co., 6 pp, ill. Metal and plastic applications of a screw with the lock washer an integral part of screw head. (285)

Steel Sheets and Wire. Continental Steel Corp., 20 pp, illus. Contains sizes, tempers, shapes and finishes of wire available and describes types of steel sheet in stock. (286)

Heat Treating Furnaces. The Electric Furnace Co., 4 pp, ill. Shows various gas, oil and electric furnaces for annealing and heat treating requirements and lists applications. (287)

Muffles and Retorts. Electro-Alloys Div., American Brake Shoe Co., 6 pp, illus, No. T-239. Describes company's high heat-resistant muffles and retorts and outlines corrosion and abrasion resistance features. (288)

Felt. The Felters Co., 22 pp. Design properties, selection and applications of felt and felt products. (289)

Friction or Damper Parts. World Bestos, Div. of Firestone Tire & Rubber Co., 4 pp, illus. Available molded parts—brake lining and blocks, transmission linings, clutch facings, thrust washers, etc. (290)

Electroforming. Gar Precision Parts, Inc., 4 pp, ill. Process permits exact reproduction of intricate details on sheet or complex forms using permanent or expendable mandrels. (247)

Electrical Insulating Materials. General Electric Co., 8 pp, illus. Lists insulating materials, including varnishes, finishes and mica mat. Properties and applications given. (248)

Rivet-Type Fasteners. B. F. Goodrich Co., Rivnut Div. Cardboard "demonstrator" illustrates working principle of Rivnuts, their construction and applications. (249)

Fasteners. H. M. Harper Co., 8 pp, ill, Vol. 19, No. 2. Various case histories of the applications of Harper's fasteners, emphasizing corrosion-resistant bolts. (250)

Decimal Equivalent Chart. John Hassall, Inc. Easy-to-read decimal-equivalent wall chart of this company's cold headed parts. (271)

Heat-Treating Furnaces. Hevi Duty Electric Co., 8 pp, ill, No. 653. Describes furnaces for annealing, stress relieving, nitriding, etc. (272)

Pyrometers. Illinois Testing Labs Inc., 6 pp, ill. Thermoelectric pyrometer for precision measurements of temperatures beyond 1000 F. (273)

Induction Heating Generators. Induction Heating Corp., 4 pp, ill. Technical data and case histories with applications of 2½- and 3½-kw induction heating generators. (274)

Die Casting Machines. Lester-Phoenix, Inc. Folder gives description, features and specifications of this company's die casting machines and injection molding machines. (282)

Electrodes and Holders. P. R. Mallory & Co., Inc., Welding Div., 2 pp, ill, No. 8-11. Advantages, design and application of 8-deg (4 deg per side) ⅝-dia spot welding electrodes and holders. (550)

Tubular Furnaces. Marshall Products Co., 4 pp, ill. Discusses both the creep test and tensile test models of Marshall tubular furnaces, as well as control panels and radial brackets. Includes specifications. (551)

Prime Coated Pressed Wood. Masonite Corp., 2 pp, illus. Properties and uses of Presdwood panels with hard, tough primer coat applied by special process at factory. (552)

Alkali Hardwood Lignin. Mead Corp., 14 pp. Outlines properties, industrial applications and chemical modifications of "Meadol". (553)

Aluminum Bronze Electrode. Metal & Thermit Corp., 20 pp, illus. Describes aluminum bronze coated electrode providing high strength, corrosion-resistant deposit for arc welding manganese bronze castings and brass sheets or plates. (554)

Rivets. Milford Rivet & Machine Co. A handy slide rule selector gives complete rivet specifications. (579)

Furnace and Oven Controls. Minneapolis Honeywell Regulator Co., 44 pp, ill, No. 54-1. Catalog and price list on Brown Instruments and Honeywell controls for industrial furnace and oven equipment. (555)

Welding Rods. Mueller Brass Co., 4 pp, illus. Describes welding rods for oxyacetylene welding of cast iron, malleable iron, steel and most copper-base alloys. (556)

Induction Brazing. The Ohio Crankshaft Co. "Typical Results of Tocco Induction Brazing and Soldering" shows by case histories the advantages of these fastening methods. (557)

Power Brush Finishes. Osborn Mfg. Co., 4 pp, ill. Automatic deburring by power brushing techniques. (558)

Tar-Base Protective Coatings. Pittsburgh Coke & Chemical Co., Protective Coatings Div. Five bulletins give detailed information concerning Pitt Chem 100 Series of tar-base protective coatings. (559)

Radiation Pyrometer. The Pyrometer Instrument Co., No. 100. Features and principle of Pyroradiation pyrometer for obtaining spot temperatures in furnaces, kilns, forgings and fire boxes. (560)

Cold Cabinet. Revco, Inc., 2 pp. Low temperature cabinet for industrial processes and research. (561)

Hardness Testers. Riehle Testing Machines, Div. of American Machine & Metals, Inc., 4 pp, ill, No. RH-1154. Portable hardness testers for Rockwell readings with scales A, B, C, D, F and G. (562)

Screws. Russell, Burdsall & Ward Bolt & Nut Co., 8 pp, ill. Presents principle of fastening, advantages and specifications of a complete line of Spin-Lock screws available in hex, pan, truss or flat heads. (563)

Tensile Testing Machines. Scott Testers, Inc., 6 pp, ill, No. 55. Shows wide assortment of testing machines for testing tensile strength of materials such as rubber, paper, wire and thread. (564)

Self-Locking Set Screws. Set Screw & Mfg. Co., 20 pp, ill. Illutrates and describes various types of standard and self-locking set screws with data on dimensions, prices, heads, points and materials. (565)

Fasteners. Simmons Fasteners Corp., 36 pp, ill, No. 1252. Detailed information on a complete line of Dual-Lock, Link-Lock, Quick-Lock, Roto-Lock and Spring-Lock fasteners. (566)

Heat Treating Equipment. Stanwood Corp., 4 pp. Brief description of types of heat treating equipment with suggested applications. (567)

Wire and Ribbon. Sylvania Parts Div., Sylvania Electric Products, Inc., 12 pp. Describes facilities for producing precision wire and ribbon, wire and ribbon parts, and plated small parts. Includes charts on chemical composition of wire and ribbon and properties of wire materials. (568)

Temperature Measurement. Tempil Corp., 8 pp, ill. Compares various methods of temperature measurement, including temperature-indicating lacquer, crayons and pellets. (569)

Recording Controller. Thermo Electric Co., Inc., 2 pp, illus, No. 62. Describes potentiometer pyrometer and resistance thermometer controllers with either two-position or pulse-proportional control action. (570)

Electric Furnaces and Controls. Thermo Electric Mfg. Co., 20 pp, illus, No. 55. Electric furnaces, temperature controllers, and hot plates for industrial use. (571)

Nut Retainers. Tinnerman Products, Inc., 8 pp, ill, No. 245-3. Specifications and descriptions of Speed Grip nut retainers offering a sure method of keeping nuts secure. (572)

Brazing Alloys. United Wire & Supply Co., 3 pp, ill. Wire brazing aluminum for low temperature brazing of various metals and alloys. (573)

Resistance Welding. Unitek Corp., 6 pp. Describes bench mounted precision resistance welder for joining small metal assemblies in electronic, instruments, and ordnance products. (574)

Heat-Treating Furnaces. Waltz Furnace Co., illus. Contains descriptive material on all types of industrial furnaces for heat treating, enameling, cyaniding and annealing in controlled and regular atmosphere. (575)

Welding Process. Westinghouse Electric Corp., 7 pp, No. B-6525. Describes performance and applications of consumable electrode inert gas welding process. (576)

Hardness Testers. Wilson Mechanical Instrument Div., American Chain & Cable Co., Inc. Engineering data, uses and design features of Rockwell hardness testers. (577)

Cold Roll Forming. The Yoder Co., 88 pp, illus. Designed as a text or reference book on the function, scope and economies of cold-roll forming. (578)

standard for comparison

...and with high speed steels the standard is REX

Living up to a standard for comparison isn't easy. That's why Crucible lavishes special care on the manufacture of REX® high speed steels... to keep REX the *standard* wherever high speed steels are used—as it has been for over half a century.

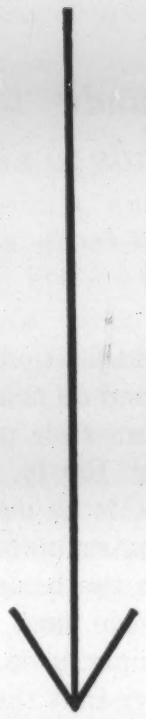
It's easy to *prove* the superiority of REX. Use it on the job... check its size, structure, response to heat treatment, fine tool performance. You'll agree with thousands of other users—*you can't find a high speed steel to outperform REX.*

Remember, REX is made only by Crucible. So call for REX at any Crucible warehouse, or for quick mill delivery. *Crucible Steel Company of America, Henry W. Oliver Building, Pittsburgh 30, Pa.*

CRUCIBLE first name in special purpose steels

Crucible Steel Company of America

For more information, turn to Reader Service Card, Circle No. 384



One point of view

Benjamin Franklin's ideas still guide many men

This month, organizations throughout the world will launch a year-long program to commemorate the 250th anniversary of the birth of Benjamin Franklin. More than 500 groups are cooperating. Although the individual groups will develop their own programs, each will try to further one of Franklin's pet projects —free and voluntary communication of ideas among peoples to help international understanding.

Franklin was famous and is remembered for many things —his inventions and scientific discoveries, his diplomatic service and his notable efforts to establish and maintain a free press. However, whether we realize it or not, most of us pay homage to the man every day of our lives by repeating some of his words of wisdom which are usually most aptly phrased.

Two of his sayings come to mind.

The first, which applies to each of us as individuals, goes:

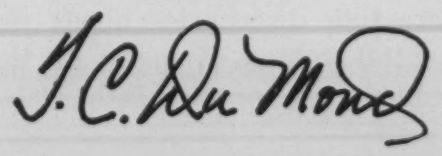
"We may make these times better if we bestir ourselves."

The second has a particular significance to those who write or supply news. He said:

"Either write things worth reading or do things worth the writing."

A third statement of Franklin's showed the vision he possessed, for several of his predictions have already come true and others are approaching. When speaking on science he said:

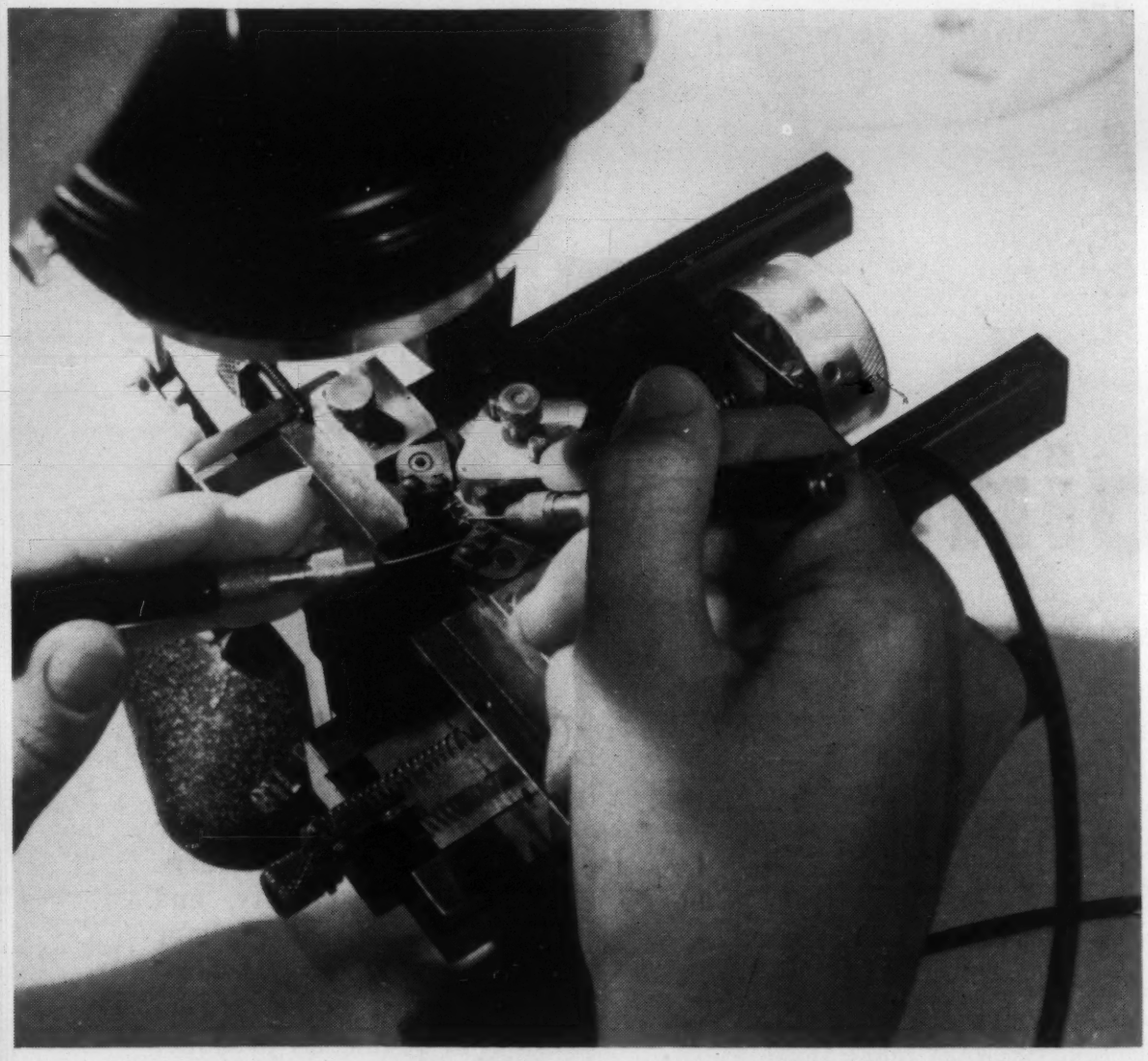
". . . . The rapid progress *true* science now makes, occasions my regretting sometimes that I was born so soon. It is impossible to imagine the height to which may be carried, in a thousand years, the power of man over matter. We may perhaps learn to deprive large masses of their gravity, and give them absolute levity, for the sake of easy transport. Agriculture may diminish its labour and double its produce; all diseases may by sure means be prevented or cured, not excepting even that of old age, and our lives lengthened at pleasure even beyond the antediluvian standard. O that moral science were in a fair way of improvement, that men would cease to be wolves to one another, and that human beings would at length learn what they now improperly call humanity."



Present and Future Uses

Fifteen metals meet this definition of a scarce metal: yearly production under 100 tons, but over 100 lb. Their commercial importance is increasing as research leads to new uses.

by Chester T. Sims, *Assistant Chief, Nonferrous Physical Metallurgy, Battelle Memorial Institute*



Tiny point contact transistors *of germanium are attached to wires under the microscope.* *(Bell Telephone Laboratories)*

■ Intensifying demands for specialized and improved materials are leading engineers to investigate the properties of all available metals. More and more effort is being expended on relatively unknown metals to determine their usefulness for alloying agents, electronic materials, nuclear applications, and other purposes. Research has led to some interesting discoveries about the potential values of many of the so-called *rare metals*. It has also demonstrated that these metals show high promise of future usefulness in solving many materials problems.

What are scarce metals?

The term *rare metals* has been used extensively and has had many meanings in the past. To avoid confusion, the term *scarce metals* will be used to designate those metallic elements which are useful and well known, yet whose production is relatively low. As a basis for classification, scarce metals are defined as those whose yearly production falls under 100 tons, but is over 100 lb. This excludes such metals as manganese, cobalt, titanium, columbium, and many others on the basis of high production. Since most of these are now commonly used in technology, it follows that they should not be termed scarce. On the other hand, most of the metals whose yearly production is less than 100 lb have little practical value and may be considered as laboratory curiosities. This leaves a group of about fifteen metals, most of which have great practical and economic value, but are sufficiently rare to limit their use to applications requiring a small amount of the metal. Radium, widely used because of its radioactive properties, would normally fit nicely in this classification, except that its production is below 100 lb per year.

Scarce metals fall into about five general classifications. Cesium is a light metal, so-called because of its low density of 1.9 g/cc. It could also be grouped with gallium, indium, and thallium, members of the large group of low-melting metals. Cesium and gallium actually become liquids on hot days; indium and thallium also melt at rather low temperatures. Rhenium, thorium, and hafnium represent the transition metals, a group of elements comprising about half of the periodic system. Thorium is also one of the most common members of the *rare earth* family of elements, which compose a large subgroup

# of Scarce Metals

within the transition metals. Ruthenium, rhodium, and palladium, the light weight group of the precious metals, and osmium, iridium and platinum, the heavy group, are often called the platinum metals since the precious metal group also includes gold and silver. Tellurium, the least valuable of the scarce metals, is called a semiconductor because of its high electrical resistivity and also because of its resemblance to such nonmetallic elements as sulfur, selenium, and oxygen. A much more valuable semiconductor metal is the element germanium, widely known for its extensive use in the electronics industry.

The scarce metals are found in all areas of the periodic system, and therefore their characteristics are quite varied. A few of the more common physical properties are summarized in a table.

USE SCARCE METALS → / FOR THESE APPLICATIONS ↓	Light Metal	Low-Melting Metals			Semi-conductors		Transition Metals			Precious Metals: Heavy			Precious Metals: Light		
	Cesium	Gallium	Indium	Thallium	Germanium	Tellurium	Rhenium	Thorium	Hafnium	Ruthenium	Rhodium	Palladium	Osmium	Iridium	Platinum
Electrical wires and filaments	—	—	—	—	—	—	0	0	X	—	X	X	0	0	X
Electrical contacts	—	—	0	—	—	—	X	—	0	X	X	X	X	X	X
Spark plugs	—	—	—	—	—	—	0	—	0	—	X	—	0	0	X
Thermocouples	—	—	—	—	—	—	0	—	0	—	X	—	—	—	X
Electron emission	X	—	—	—	—	—	0	X	0	—	—	—	0	—	—
Semiconductors	—	X	X	—	X	—	0	—	—	—	—	—	—	—	—
Electroplates	—	0	0	—	—	—	0	—	—	0	X	X	0	0	X
Corrosion resistance	—	—	—	—	—	0	0	—	—	—	X	X	—	X	X
Glass and rayon spinnerettes	—	—	—	—	—	—	0	—	—	—	X	—	0	X	X
Laboratory ware	—	—	—	—	—	—	—	—	—	—	—	X	—	X	X
Refractories	—	—	—	—	—	—	—	0	—	—	—	—	—	—	—
Additions to nonrare alloys	—	—	0	—	—	X	—	X	—	—	—	—	—	X	—
Dental alloys	—	—	X	—	—	0	—	—	—	—	—	X	—	—	X
Wear resistance	—	—	—	—	—	—	X	—	—	X	X	—	X	0	X
Low melting alloys	0	X	X	0	—	—	—	—	—	—	—	—	—	—	—
Thermometers	0	X	—	—	—	—	—	—	—	X	X	X	—	X	X
Jewelry and decorative	—	—	—	—	—	—	—	—	—	X	X	X	—	—	X
Catalysts	X	X	—	0	0	—	X	—	—	—	—	—	—	—	—
Medicine	—	—	X	X	—	—	0	—	—	—	—	—	—	—	—
Nuclear energy	—	0	0	—	—	—	—	X	X	—	—	—	—	—	—
Radioactive	—	0	—	—	—	—	—	—	—	—	—	—	—	—	—
Bearings	—	—	X	—	—	—	—	—	—	—	—	—	—	—	—
Glass sealing	—	—	X	—	—	—	—	—	—	—	—	X	—	—	—
Light sensitive	—	—	0	X	—	—	—	—	—	—	—	—	—	—	—
Lubricants	—	—	0	—	—	—	—	—	—	—	—	—	—	—	—
Rectifiers	—	—	—	—	0	0	—	—	X	—	—	—	—	—	—
Insecticides	—	—	—	X	—	—	—	—	—	—	—	—	—	—	—
Vacuum "getter"	X	—	0	—	—	—	—	—	—	—	—	—	—	—	—

X = Present uses
O = Potential uses

Low-melting metals

In addition to these basic physical properties, the scarce metals have interesting characteristics that cause demand for them in technical applications. Low-density and low-melting cesium is not in demand as a result of obvious physical properties but because of a low thermionic work-function at room temperature, which makes it ideal for use as an emitter of electrons in photoelectric cells. In addition, its high affinity for oxygen makes it useful as a "getter" for gaseous impurities in vacuum tubes. Like most other scarce metals, cesium occasionally finds use as a chemical catalyst, especially in the polymerization of resinous materials.

The three other metals classified as low melting are gallium, indium, and thallium. Part of the demand for the first two is a direct result of their unique melting points. Gallium was first used like mercury as the indicator fluid in high-temperature quartz thermometers. Gallium and its alloys have been investigated recently for use as heat-exchange fluids in nuclear-power reactors. Gallium has a low vapor pressure which is beneficial, but it is also very corrosive, rather expensive, and has not yet been used successfully in this application. Other

PHYSICAL PROPERTIES OF SCARCE METALS

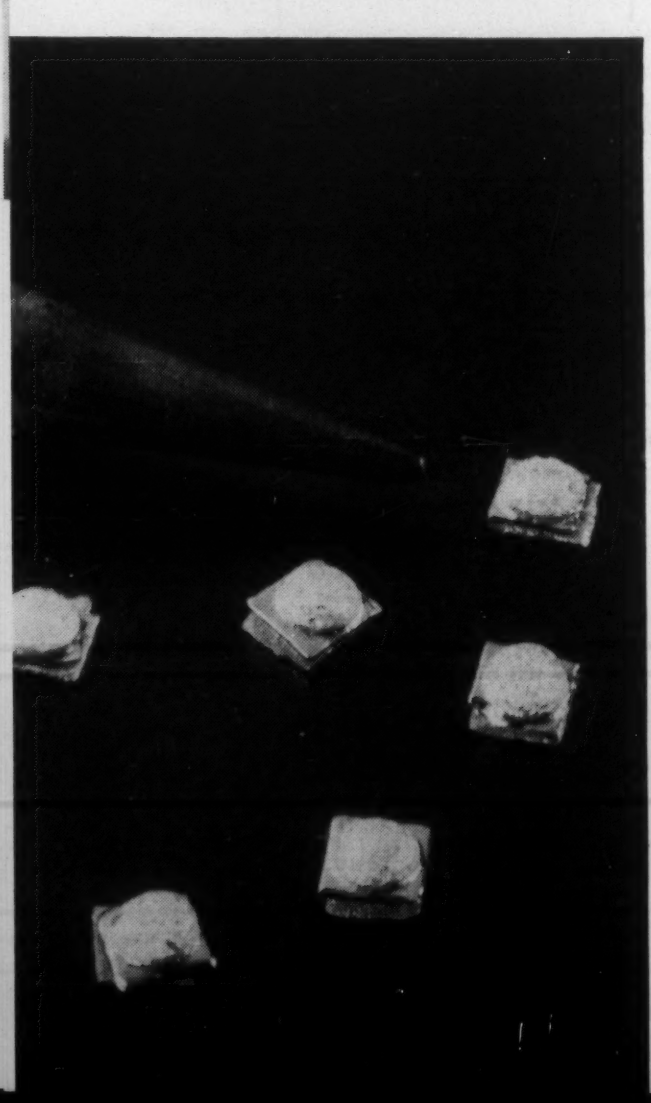
Metal	Atomic Number	Atomic Weight	Density		Melting Point		Electrical Resistivity
			g/cc	lb/cu in.	C	F	microhm-cm
Cesium	55	132.9	1.9	.069	28	82	18.8
Gallium	31	69.7	5.9	.213	30	86	56.8
Germanium	32	72.6	5.3	.191	958	1757	60×10^6
Hafnium	72	178.5	13.1	.473	2000	3530	32.4
Indium	49	114.8	7.3	.264	156	314	8.4
Iridium	77	193.1	22.5	.83	2554	4449	5.3
Osmium	76	190.2	22.5	.83	2700	4892	9.5
Palladium	46	106.7	12.0	.434	1554	2829	10.8
Platinum	78	195.2	21.5	.777	1774	3224	9.8
Rhenium	75	186.3	21.0	.759	3180	5756	19.5
Rhodium	45	102.9	12.4	.448	1966	3471	4.5
Ruthenium	44	101.7	12.2	.441	2500	4352	7.6
Tellurium	52	127.6	6.2	.224	450	842	2000
Thallium	81	204.4	11.8	.426	300	572	18.0
Thorium	90	232.1	11.7	.423	1840	3344	18.6

minor uses for gallium are as a catalyst, phosphor exciter, dental alloy ingredient, and cancer treatment material.

Indium, which is similar to gallium chemically, but has a higher melting point, has much broader use than production figures suggest. Alloys prepared for very-low-melting purposes usually contain indium in amounts up to 25%. These alloys are used in such applications as heat-sensitive safety plugs. Indium also increases the wettability and strength of solders, and will wet glass. A 50% tin-indium alloy is currently used for this purpose. Indium has been used in sleeve bearings plated on lead over a silver or copper base which in turn is backed up by steel. The indium coating is diffused into the lead to improve corrosion resistance, but recently this use has fallen off in favor of cheaper alloys.

Thallium finds little use in the pure or alloyed form, but has several applications as a compound. It is used principally as thallium sulfate in rodent and insect control. An interesting and unusual use for synthetic thallium halide crystals is transmission of long-wavelength infrared radiations, utilized in spotting scopes for nighttime infantry sniping, and for nighttime military signaling. Adapted to civilian use, thallium salts are now used in infrared achromatic lenses and as components for infrared spectroscopy and microscopy.

Indium disk *fused to germanium wafer to produce rectifiers for converting alternating to direct current.*



Semiconductor metals

Applications of the two rare semiconductor metals, tellurium and germanium, are quite different. While the semiconductor properties of germanium have been widely exploited, tellurium has been bypassed. It has been investigated for use as a high-temperature rectifier, but this application has not yet worked out. Instead, tellurium is primarily used as a minor additive in metallic alloys and rubber. It enhances the machinability of copper, while lowering the electrical conductivity only slightly. In copper alloys such as brass and bronze, it is used to increase machinability, strength and corrosion resistance. When added to cast iron it induces "chill" during casting. With magnesium, tellurium is used as a spheroidizer in the preparation of ductile cast iron. Tellurium acts as a vulcanizing agent when added to rubber.

In contrast with these uses of tellurium in the large volume metal industries, germanium has been utilized in an industry concerned primarily with delicate devices. Germanium was used first for diode crystal rectifiers, tiny devices consisting of small germanium disks, each in contact with a fine wire of an appropriate metal, the entire assembly being about the size of a pencil eraser. These crystal rectifiers have many advantages over vacuum tube diodes in certain functions. About 10 million are manufactured annually.

Development of the germanium diode during World War II was followed by the introduction of the point-contact-type transistor in 1948. This is a germanium triode which is similar to a diode but has two wires making contact with the germanium wafer. A further important development has been the junction-type transistor. This device, consisting of a block of germanium which has been carefully treated so that the

properties of the ends differ from those of the center, operates through area effects rather than the point effects described above. Germanium transistors and diodes can replace vacuum tubes in applications such as amplifiers and oscillators, and can also function in some applications where vacuum tubes are unsuited.

Transition group

Three of the scarce metals, rhenium, thorium, and hafnium, have been classified as members of the large transition metal group (the precious metals are also transition metals, but are considered as a separate subgrouping).

Rhenium has little in common with thorium and hafnium, chemically or metallurgically. It is the highest melting and one of the most dense of the scarce metals. It is a tough, corrosion-resistant refractory metal that forms a unique conducting oxide when used as an electrical contact. It is particularly suited to marine and to certain high-temperature types of service. In addition, its high resistance to the "water cycle" (a deleterious phenomenon occurring in moderate vacuum which causes material transfer from a hot filament to the colder surrounding wall) bodes well for its use in electron tubes. Rhenium has also been used for pen points, filaments for evaporation of liquid metals, and as a catalyst.

Thorium finds application as a metal, and also as the oxide, ThO_2. The nonenergy use of metallic thorium has been mainly confined to gaseous discharge lamp filaments. Thorium oxide has found considerable application as an incandescent gas mantle. Another of its more important uses is as an additive to tungsten filaments, where it controls grain size to reduce burn-out at incandescent temperatures. In addition, thorium oxide is added to tungsten to lower the work function in thermionic emission applications. It is also used in other electronic applications. Because of its very high melting point, it has limited use as a high-temperature refractory. In addition, it is a prospec-

Sources, Supply and Costs

Scarce metals are obtained from all of the earth's continents, although North America is the prime producer when the group is considered as a whole. For instance, Canada and the United States combined produce about 45% of the world's supply of the precious (or platinum) metals. South Africa produces about 30% and the Soviet Union an estimated 15%. Data on the entire group are given in a table. Actual production figures for hafnium and thorium are not known. However, thorium is a popular metal for nuclear energy applications and it is quite possible that the yearly production is sufficient to take it above the classification limits drawn here for scarce metals. Some of the other rare earth metals may fall within the 100 lb to 100 ton range, but most of these elements are not separated one from the other and are marketed in a combined form called misch metal.

Metal	General Classification	Principal Sources	Approx World Production,[1] tons/year	Approx cost as pure metal, Dollars per	
				gram	pound
Cesium	light, low melting	Africa, United States	30	0.50	225[2]
Gallium	low melting	United States, England, Europe	0.25	3.00	1500
Germanium	semiconductor	Africa, United States	5-10	0.70	300
Hafnium	transition	United States, Australia	—	25.00[3]	—
Indium	low melting	Europe, Asia, North America	7	.08	35
Iridium	precious	Canada, S. America, USSR, Africa	0.4	3.50	1500
Osmium	precious	Canada, S. America, USSR, Africa	0.2	3.50	1500
Palladium	precious	Canada, S. America, USSR, Africa	12	0.65	300
Platinum	precious	Canada, S. America, USSR, Africa	12	2.50	1100
Rhenium	transition	United States, Germany, USSR	1	2.25	1000
Rhodium	precious	Canada, Africa, USSR, S. America	1	4.00	1800
Ruthenium	precious	Canada, Africa, USSR, S. America	0.5	1.75	800
Tellurium[4]	semiconductor	United States, Europe, Australia, Canada	50-60	0.003	1.75
Thallium	low melting	United States	20	0.02	12.50
Thorium	transition	United States, India	—	0.75	350

[1] *Production is in any form, but reported as tons of contained metal.*
[2] *Reported as cost of cesium salts.*
[3] *Price expected to drop to about $150 per pound.*
[4] *Although tellurium is usually termed a metal, many of its properties are similar to those of uonmetals like sulfur and selenium.*

tive atomic fuel for nuclear reactors, an application which could outstrip the more common uses.

Hafnium has few applications. It has been investigated for use in X-ray tubes, rectifiers, and other electronic devices. It has been suggested as an alloying ingredient in resistance heater wires. However, lack of complete information on its properties has severely hampered development. Formerly, difficulty of separating the metal from zirconium, with which it occurs, was cited as the main cause of this. Recently these processes have been improved as a result of the need for low-hafnium zirconium for nuclear-energy purposes. Preliminary information indicates that hafnium has interesting physical properties. As more becomes known about the metal, its use will increase.

Precious metals

The platinum group of the precious metals is one of the better-defined groups in the periodic system. Properties of the member metals are quite similar. Generally they are high melting, ductile, and corrosion resistant. Their pleasant appearance and nobility, as with gold and silver, have brought about extensive use in the jewelry industry. This has undoubtedly contributed to the use of the term "precious". However, industrial and scientific importance far transcends their use as decoration. Platinum, most plentiful and most corrosion resistant of all metals, is used pure and alloyed for thermocouples, resistance devices, furnace windings, crucibles, filaments, electrodes, vacuum tube construction materials, catalysts, and many other less common devices. In addition, it is widely used in electrical contacts, spark plugs, spinnerettes in the organic fiber industry, and in dental metallurgy.

Properties of the other precious metals differ somewhat from platinum. Most are less corrosion resistant, and while platinum is one of the easiest of metals to fabricate, osmium, iridium, and rhodium are very difficult to work. In fact, osmium is presently considered totally unworkable, as it is brittle even at high temperatures. Nevertheless, as a group, all of the precious metals are dense, high melting, and corrosion resistant. All have been used in electrical-contact alloys and most have some corrosion-resistant application. Osmium is used in phonograph needles and pen tips, often in combination with iridium as a naturally occurring alloy called osmiridium. Iridium is used to harden platinum, which is too soft and ductile to be used for items like spinnerettes and jewelry mounts in the pure state.

Rhodium-platinum alloys are common. The well-known platinum-10% rhodium alloy is used in such widely varying applications as thermocouple elements, glass extrusion equipment, catalysts, and high-quality spark plugs. Electroplated rhodium is becoming increasingly important, and is used in reflectors for search lights, as a final coating in jewelry and so forth. Ruthenium is used primarily as a hardening element for platinum. Platinum-ruthenium alloys are well-known in the electrical contact field where they are employed in aircraft magnetos.

Palladium, least dense and least expensive of the precious metals, is also one of the most workable. It is similar to platinum chemically and, next to platinum, has the widest range of uses of the group. Palladium and its alloys are in demand as contact materials, for dental alloys, and as decorative leaf. Palladium is also used as a catalyst in the preparation of antibiotics and vitamins.

Scarce metals potential

Although the total yearly production of the scarce metals is only about 150 tons, they form an important segment of today's technology. Economically, the scarce metals industry is also important, with a production valued near $125 million per year—about a million dollars per ton. Both the economic and technical importance of this group will increase as research brings new uses to light.

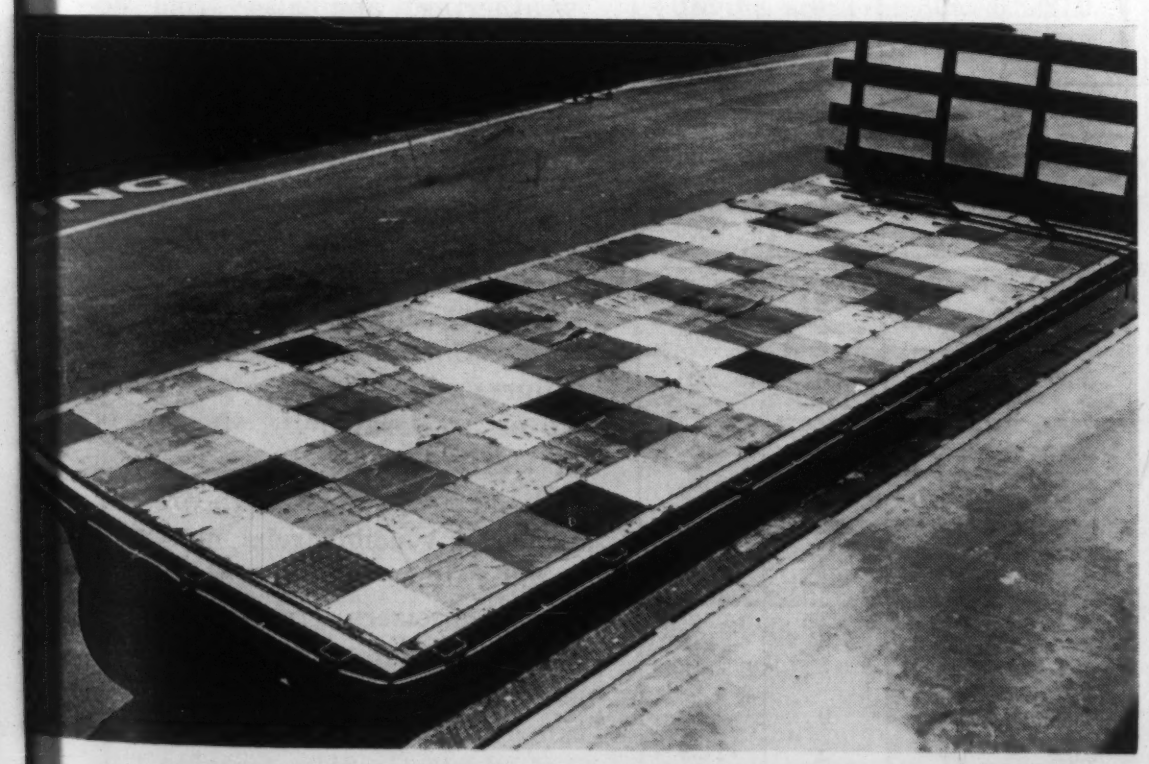
For germanium, the platinum group metals, and thorium, the limited supply keeps demand and price high. Thus, there is no apparent need for studies of these metals to increase their applications. Instead, conservation devices may be warranted occasionally to conserve their supply. However, silicon is becoming increasingly important as a transistor material and may replace germanium causing a relative surplus of the latter.

Several of the metals suffer from a vicious cycle. There is no demand for them because the price is overly high; also, their properties have not been sufficiently revealed to create specific applications. In these cases, the government often assists by sponsoring basic research, the results of which are available to the public and serve to stir interest in the metal. This has been true in the case of rhenium. Two years ago it was virtually unknown and available only in limited laboratory quantities as a metal powder. In recent Air Force-sponsored investigations at Battelle Memorial Institute its basic physical, mechanical, and electronic properties were determined. This served to uncover some excellent electrical and electronic properties. Rhenium may now be ordered in common solid fabricated forms commercially and is finding increasing industrial acceptance.

Cesium, gallium, hafnium, and indium are in various stages of this type of development today, although none is expected to have as sharp a rise from obscurity as rhenium. Tellurium and thallium, on the other hand, suffer from overproduction. They are available as by-products of other metallurgical operations, and in many areas, tailings and sludge rich in these metals have accumulated. However, evaluations have been made and current technical investigations may soon create new uses for these two previously unneeded scarce metals.

Floor coverings of cargo-carrying aircraft are subjected to severe wear. So are floors of trucks, trains and ships. *(Pan American World Airways)*

Problem: How to Select Floor Covering Materials for Heavy Service



Service conditions are simulated by mounting test panels on cargo trailer.

Solution:

Evaluate durability of materials under simulated service conditions. Then develop laboratory requirements that correlate with test results.

by S. Polis, *Plastics Technologist, Aeronautical Materials Laboratory, Naval Air Experimental Station*

■ Selecting floor covering materials that will withstand the severe conditions encountered in aircraft, trucks, trains, ships, and similar installations is no easy matter. Perhaps the soundest approach to this difficult selection problem is to evaluate the durability of various materials under simulated service conditions and then determine a laboratory requirement to correlate with the service results.

This approach proved successful at the Aeronautical Materials Laboratory of the Naval Air Experimental Station. The program involved subjecting the test materials to service conditions even more vigorous than those generally encountered in actual use. A realistic abrasion test requirement was then established based on the results.

A number of different commercial floor covering materials were tested including linoleum, paper-phenolic laminates, cork, neoprene, and vinyl plastic. Of these, all cork, linoleum, and paper-phenolic laminates proved unsatisfactory whereas neoprene-based compositions, cork-filled vinyl, asbestos-filled vinyls, and vinyl (unknown filler) were acceptable.

Evaluating wear

The simulated service test consisted of mounting five test panels of each material on a cargo trailer and putting the trailer in actual service for transporting all types of cargo at the Naval Air Material Center in Philadelphia for a period of eight months. Two such tests were conducted. The results of evaluation are given in a table.

The method of rating the floor covering materials was based on several factors. Since an impact blow from a sharp object such as a protruding nail might possibly damage a panel, one exposure less than ⅛ in. sq was allowed. The chance that this would occur on more than one panel was unlikely because of the arrangement of

specimens (see test methods). On the other hand, a delamination producing an area of 1 in. sq was considered a failure, since such a delamination would tend to increase in size under any subsequent stress. Also, a delamination is usually accompanied by surface tearing. This would indicate inferior tear strength as well as poor interlaminar bonding.

EVALUATION OF FLOOR COVERING MATERIALS

Specimen No.	Approximate Composition	Weight, oz/sq ft	Thickness, in.	Service Test		Abrasion Test
				No. Worn Through	No. De-laminated	Avg No. of Cycles
1a	Linoleum	7.03	0.070	2	2	445
1b	Linoleum	9.91	0.093	2	0	1020
2	Paper-phenolic laminate	6.07	0.066	2	0	850
3	Paper-phenolic laminate	13.5	0.131	0	0	1884
4	Cork	8.47	0.182	4	0	860
5	Rubber, neoprene base	15.45	0.137	1	0	2000+
6a	Rubber, neoprene base, two layers	21.4	0.155	1	4	2000+
6b	Rubber, neoprene base, two layers	22.7	0.157	0	2	2000+
6c	Rubber, neoprene base, two layers	18.1	0.156	1	3	2000+
7	Rubber, neoprene base	8.31	0.059	2	0	1415
8	Rubber, neoprene base	13.4	0.122	1	0	2000+
9	Rubber, neoprene film, solvent-activated adhesive	1.44	0.021	5	0	127
10	Vinyl, unfilled	9.60	0.110	0	0	2000+
11	Vinyl, unfilled	5.91	0.063	5	0	1599
12	Vinyl film, solvent-activated adhesive	0.640	0.017	4	0	195
13	Vinyl, cork filled	16.9	0.125	1	0	2000+
14a	Vinyl, asbestos filled	20.2	0.123	0	0	2000+
14b	Vinyl, asbestos filled	14.8	0.109	0	0	2000+
15	Vinyl, asbestos filled	18.7	0.120	0	0	2000+
16a	Vinyl, unknown filler	19.5	0.130	0	0	2000+
16b	Vinyl, unknown filler	11.3	0.082	0	0	1120
17	Vinyl, inlaid	5.75	0.075	3	1	245
18a	Vinyl coating on glass fabric	2.20	0.029	3	0	226
18b	Vinyl coating on glass fabric	2.82	0.041	4	0	929
18c	Vinyl coating on glass fabric	2.14	0.029	3	0	486
19	Vinyl coating on glass fabric	2.90	0.032	4	5	1139
20	Vinyl coating on glass fabric	4.45	0.047	4	0	1212
21	Vinyl coating on broadloom	3.84	0.048	3	0	1111
22	Vinyl coating on cloth	4.47	0.041	5	0	925
23a	Vinyl film, felt backed	5.60	0.072	1	5	192
23b	Vinyl film, felt backed	5.91	0.073	0	5	161
24	Unknown	5.75	0.070	1	3	178

To establish a realistic abrasion requirement that would correlate the service test results, abrasion tests were run to determine an empirical value. As a result of these tests, it was found that five abrasion test specimens should withstand a minimum of 2000 cycles in order to pass the proposed abrasion requirement. This value resulted from the fact that of the eleven materials which abraded a minimum of 2000 cycles, only three failed the service test, and these three failed as a result of delamination. Some materials failed only because the thickness of the materials as received did not meet the final requirement decided upon.

Aging and delamination

Besides obtaining information for establishing a realistic abrasion requirement, two other factors were learned from the service test. They were that service failure could occur from aging or weathering, and also from delamination. Neither of these failures could be predicted through an abrasion test.

Failure of vinyl materials in storage under no stress has occurred from plasticizer migration in the case of plastic wire insulation. For this reason, a weathering test may be able to predict failures which are only partly due to, or accelerated by, the effects of weathering.

Since it was not known whether or not any commercial materials would fail by aging due to fugitive plasticizers (resulting from one or a combination of the following factors: volatility, extraction, migration, and exudation), a vinyl plastic floor covering material with 35 PHR of trioctyl phosphate plasticizer was service tested (No. 11 in the table) and failed. In addition, another floor covering material using tricresyl phosphate as a primary plasticizer was made and service tested

(No. 10). This material passed the service test. Comparative data on two plastic films containing these plasticizers are as follows:

Plasticizer	Volatility 70 C, % Loss	Water Extraction, % Loss	Lacquer Mar 24 hr
Flexol Triocytyl Phosphate (used in No. 11)	3.4	0.21	Extra Heavy
Tricresyl Phosphate (used in No. 10)	0.3	0.00	Trace

Loss of trioctyl phosphate in No. 11 from volatility (over 11 times that of TCP) and water extraction (rain) seems quite probable. Lacquer mar is an indication of migration characteristics and is partly dependent upon the pressure of the contacting surface. Since cargo crated in wooden boxes was sometimes very heavy, migration of plasticizer into cellulosic materials such as wood and paper may have been considerable. Regardless of the reason, loss of plasticizer from No. 11 did occur. The over-all effect was shrinkage and embrittlement of the material causing a combination of stresses near the screw heads.

It was decided that the abrasion test could not be relied upon to predict this type of failure. Also, tensile evaluation would be impractical because several of the materials were glass fabric-backed. A comparison of hardness evaluations before and after accelerated weathering was required.

Specimen No. 11 showed an average change of Shore A hardness of −9 whereas the highest change of hardness of the other materials tested was −6. Therefore, a maximum average change of hardness of ±6 was considered tolerable. It should be noted that although No. 11 only went 1599 cycles in the abrasion test, it was assumed that a material of the same composition but slightly thicker would have passed the abrasion test but failed in an actual service application. Therefore, an accelerated test was needed to screen out this type of material.

To devise a test that could predict delamination failure of a floor covering material would be quite difficult in view of the fact that the surface laminations of the materials evaluated had thicknesses varying from approximately 0.010 to 0.125 in. It was therefore decided that only homogeneous non-laminated materials should be considered for cargo floor covering applications.

Acknowledgment

Appreciation is expressed to other members of the Aeronautical Materials Laboratory who assisted in this investigation, including two former members, Harry J. Doyle and Joseph L. Castelli.

Adapted from NAMC Report No. AML NAM AE 5241, "Investigation, Test and Development of Floor Covering Material for Aircraft" of 5 January 1955.

The opinions or assertions in this article are those of the writer and are not to be construed as official or reflecting the views of Navy Department or Naval Service at large.

How Tests Were Made

Service test

The trailer was covered with seven columns of test materials; the outer two columns, however, were not evaluated since they served as buffers to protect the five test columns from edge blows. Five one-foot-square panels for each of twenty floor covering materials were tested simultaneously, with each floor covering material occurring only once in each test column and only once in each group of four rows. This arrangement of panels is known as a modified latin square and minimized the possibility of chance failure of two of any five test panels because of a protruding nail or other sharp object which would impose an extreme local stress.

Abrasion test

The abrasion wear test apparatus was a Schiefer Abrader. Test specimens were bonded to five 2 in. aluminum disks and were subjected to a continuous rubbing action of Behr Manning 80-E(0), Closekote Durite Paper (D) under a total load of 7 lb. The surface of the test sample was brushed every 25 cycles on all materials that had a tendency to form little particles that would "ball up" and prevent contact with the abrasive. The abrasive was changed every 250 turns or cycles.

Weathering test

In the accelerated weathering test, two 1 by 6 in. specimens were hung vertically for 250 hr in a weatherometer with the wearing surface of the material facing the carbon arc. After removal, the wearing surface was tested for hardness with a Shore A Durometer. The test specimens were cut into one-inch squares and stacked until a thickness of ¼ in. was attained. The use of a ¼ in. thickness rather than one thickness of material as received (which would simulate end use) is justified on the basis that the information desired is a change in hardness before and after conditioning in order to predict service failure due to weathering and aging. On thin floor covering materials (vinyl coated fabrics), such change in hardness values would be considerably affected by the supporting surface on which test is made.

Boron Nitride

A new ceramic material with

High Temperature Stability

Temperature limitation	May be used up to 3000 F for most applications and at higher temperatures under special conditions.		
Thermal shock resistance	Very good.		
Oxidation in air, loss in weight, mg/sq cm	**Hr**	**1300 F**	**1800 F**
	2	0.014	0.35
	10	0.062	0.85
	30	0.138	4.8
	60	0.235	10.0
Resistance to chlorine, loss in weight, mg/sq cm	**Hr**	**1300 F**	**1800 F**
	3	—	2.7
	20	0.25	17.0
	40	0.55	—
Modulus of rupture, psi	**Temp, F**	**Direction[2]**	**Direction[1]**
	75	15,880	7280
	570	15,140	7030
	1300	3840	1900
	1800	2180	1080
Modulus of elasticity, psi x 10^6	**Temp, F**	**Direction[2]**	**Direction[1]**
	75	12.36	4.91
	570	8.79	3.47
	1300	1.54	0.51
	1800	1.65	—
Thermal conductivity C.G.S. units	**Temp, F**	**Direction[1]**	**Direction[2]**
	570	0.0687	0.0362
	1300	0.0646	0.0318
	1800	0.0637	0.0295
Coefficient of thermal expansion - cm/cm°C x 10^{-6}	**Temp, F**	**Direction[1]**	**Direction[2]**
	75-660	0.59	10.15
	75-1300	0.89	8.06
	75-1800	0.77	7.51

Good Electrical Properties[3]

Dielectric constant[4] (baked and desiccated specimens)	**Frequency, cyles/sec**	**Dielectric constant 75 F**	**660 F**	**900 F**
	10^2	4.15	4.4	9.0
	10^4	4.15	—	4.5
	10^6	4.15	—	4.25
	10^8	4.15	—	—
Dissipation factor[4] (baked and desiccated specimens)	**Frequency, cycles/sec**	**Dissipation factor 75 F**	**660 F**	**900 F**
	10^2	0.00103	0.032	1.0
	10^4	0.00042	0.0043	0.1
	10^6	0.00020	0.0012	0.0056
	10^8	0.000095	—	—
	10^{10}	0.0003	0.0004	0.0005
Resistivity vs temperature (dry specimens)	**Temp, F**	**Resistivity, ohm-cm**		
	75	1.7×10^{13}		
	900	2.3×10^{10}		
	1800	3.1×10^4		
Resistivity vs humidity	**Relative humidity, %**	**Resistivity at room temp, ohm-cm**		
	20	10^{12}		
	50	7×10^{10}		
	90	5×10^9		

[1] *Testing force applied perpendicular to direction of forming pressure.*
[2] *Testing force applied parallel to direction of forming pressure.*
[3] *Measurements made with electric field parallel to the pressing direction except at 10^{10} frequency the electric field was perpendicular to the pressing direction.*
[4] *Data obtained by the Laboratory for Insulation Research, Massachusetts Institute of Technology.*

by **K. M. Taylor,**
Research and Development Div.,
The Carborundum Co.

■ A new ceramic material, consisting of 43.6 boron-56.4% nitrogen, has a unique combination of properties which suggests many interesting applications at temperatures up to about 3000 F and at higher temperatures under special conditions. Though as yet no commercial applications have been proven, it would seem to offer distinct advantages for such uses as rocket nozzles, crucibles for melting reactive metals and salts, combustion chamber liners, bearings and bearing components, gaskets, equipment for handling molten glass, and pump parts for handling certain molten metals. Its electrical characteristics suggest uses such as insulators, vacuum tube separators and other dielectric applications.

A high priced material compared with ordinary ceramics, it is available in moderate quantities at prices that will be substantially reduced when volume warrants commercial scale production.

General characteristics

The crystal structure of pure boron nitrite powder consists of flat platelets that slip easily over each other providing a lubricating effect. Sometimes called "white graphite" because of the similiarity in structure, the material is usually hot pressed into a dense form or combined with metallic or nonmetallic powders to form a variety of new materials. The hot press process produces an easily machinable, ivory-like form with a density of 2.1 to 2.15 g/cc (theoretical maximum density is 2.25 g/cc). In the hot pressed form the material is approximately 97% boron nitride and has a hardness of 2 on the Moh's scale. Its compressive strength perpendicular to forming pressure is 34,000 psi; parallel to forming pressure it is 45,000 psi. Paradoxically, it has a resistance to sand blast erosion equivalent to that of plate glass. Its machinability is about the same as graphite.

Physical properties

At low temperatures, hot pressed boron nitride is stronger than most refractory materials. It exhibits substantially the same strength up to about 650 F. Between 650 and 1300 F strength decreases rapidly, though above 1400 F rate of strength loss decreases. Due to a partial crystal orientation during hot pressing, the present material shows a directionalism in both compressive and transverse strength characteristics.

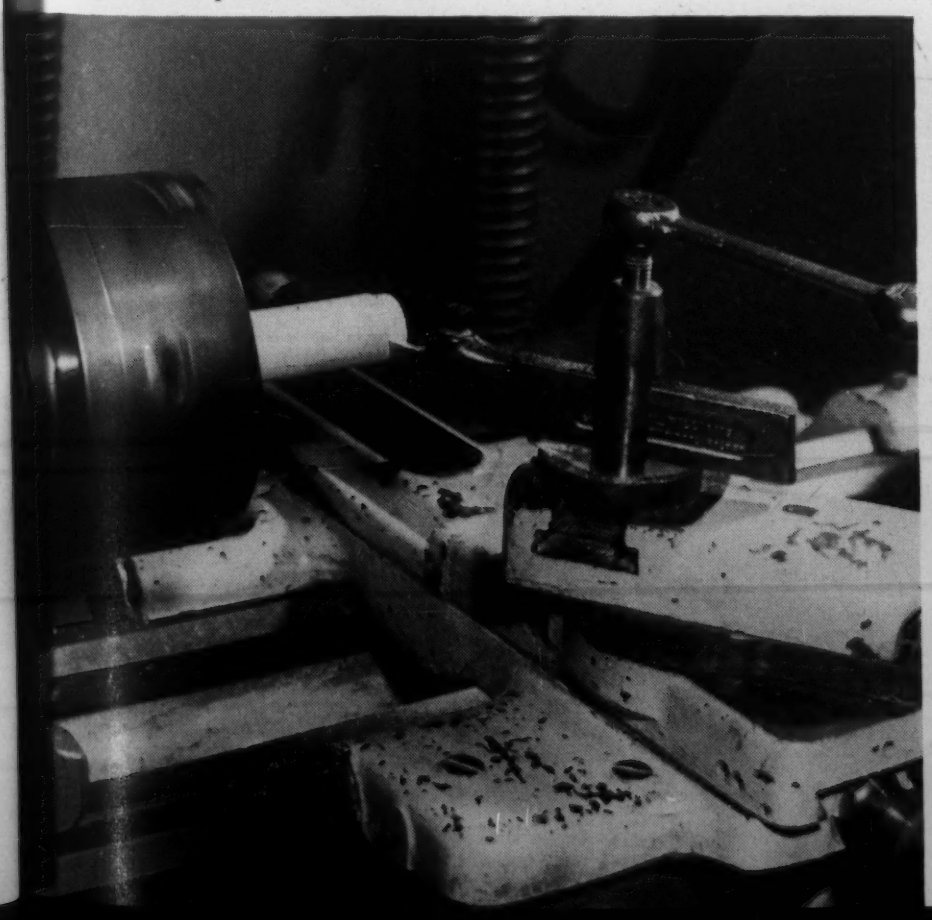
Directionalism is present in all physical properties measured and is marked in the case of thermal

What can boron nitride do for you?

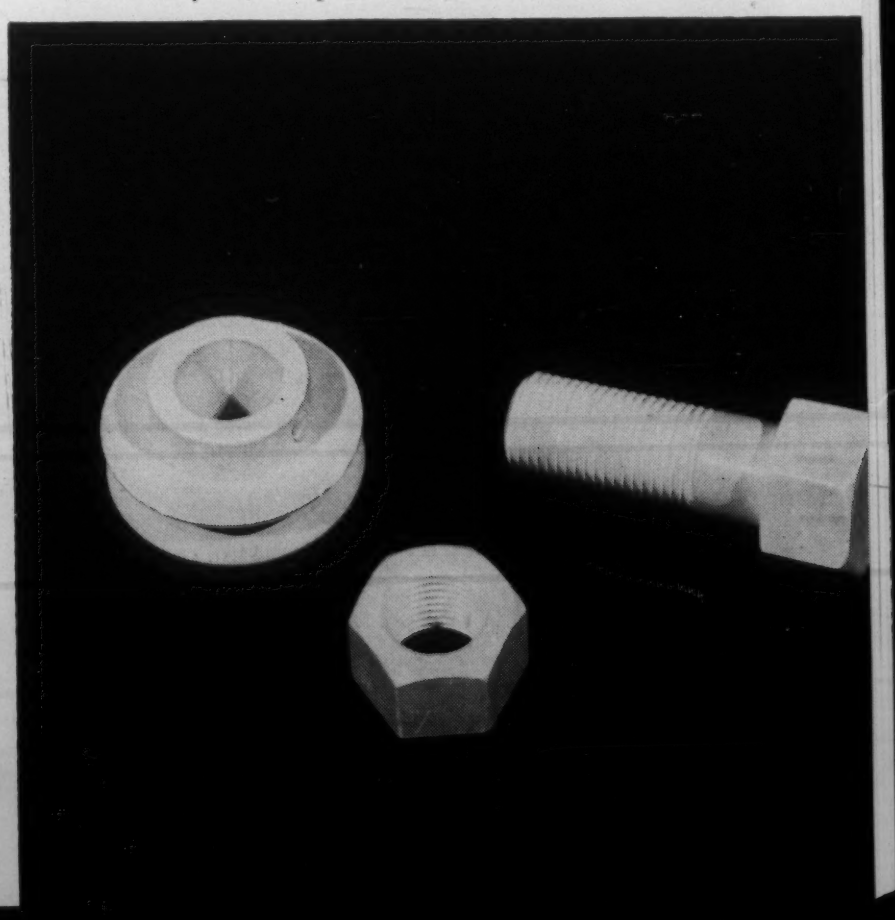
The unique combination of properties possessed by the new material includes:

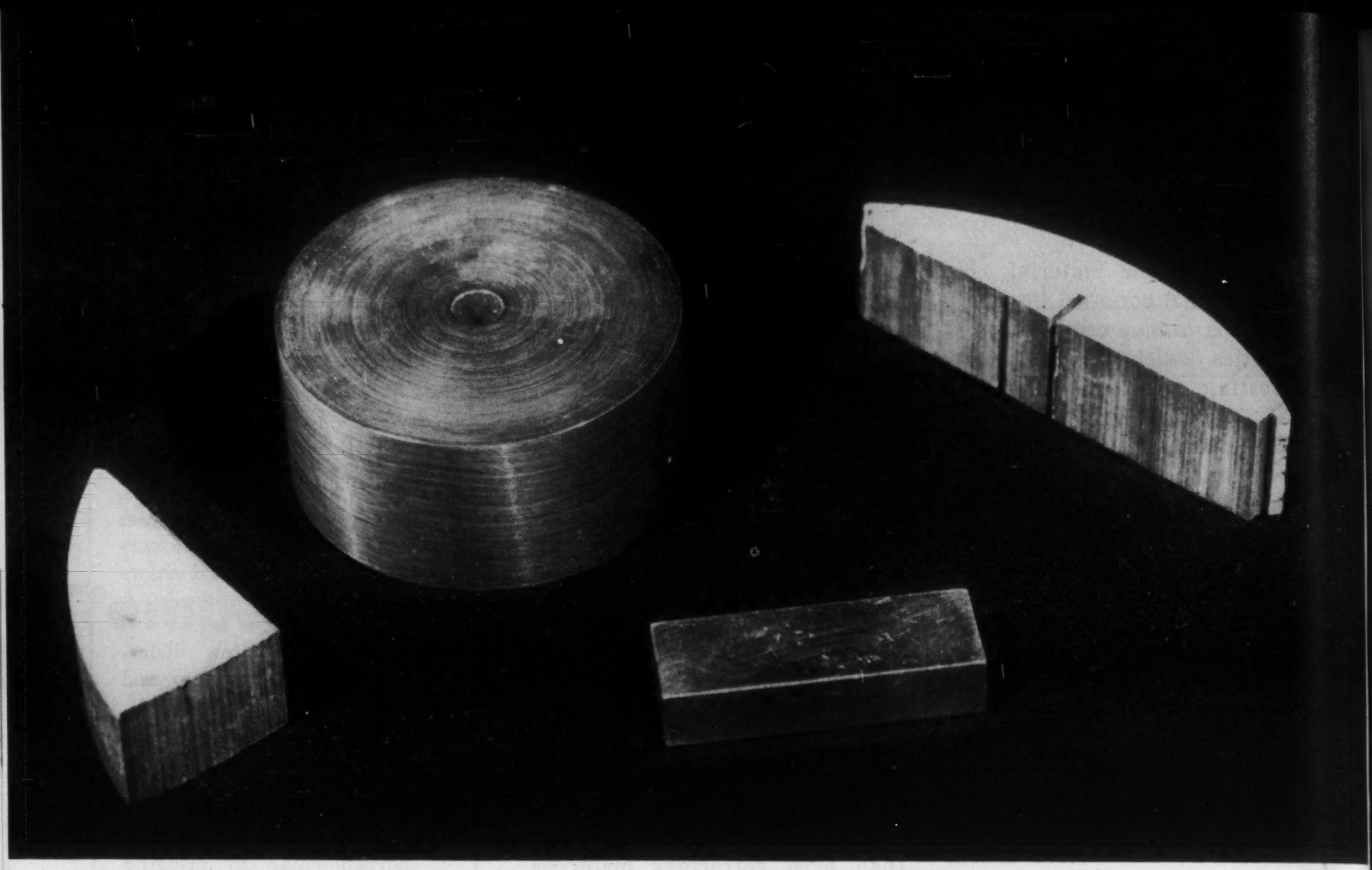
1. Resistance to corrosion by molten cryolite and aluminum.
2. Non-wettability by molten and plastic glass and certain metals such as silicon, aluminum and bronze. After prolonged contact with molten glass the surface of the material shows a slight discoloration.
3. Low porosity.
4. Comparatively low dielectric loss factor up to and at very high frequencies.
5. High electrical insulating properties.
6. Excellent thermal conductivity.
7. Low thermal expansion perpendicular to pressing direction.
8. Resists corrosion by chlorine up to 1300 F.
9. Stable in inert atmospheres or vacuum up to at least 3000 F.
10. Resists corrosive acids.
11. Has lubricating qualities similar to graphite.
12. Comparatively light in weight.
13. Can be easily machined to close tolerances with steel tools.

Lubricity and ease of machining *simplify accurate forming of the hot pressed material.*



Ivory-like appearance *is shown by these parts machined from hot pressed boron nitride.*





Cobalt-boron nitride *compositions show possibilities of combining new material with metals.*

expansion. Tests indicate that there is ten times as much expansion in a direction parallel to pressing force as there is perpendicular to pressing force when the material is heated to 1800 F. However, expansion characteristics are greatly influenced by density of the hot pressed solid. Expansion characteristics, both parallel and perpendicular to direction of pressing can be controlled by pressing to a predetermined density. Thermal conductivity, when compared with that of other ceramic materials, is good.

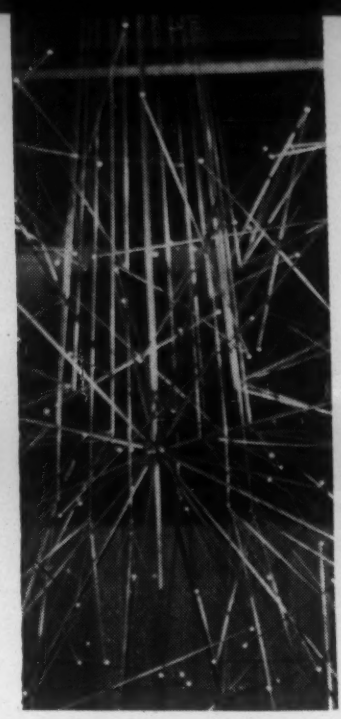
Chemical stability of hot pressed boron nitride is excellent in air up to about 1300 F. From 1300 to 1800 F rate of oxidation increases moderately. Chlorine has little effect on the material up to 1300 F, but at 1800 F attacks it rapidly. Fused sodium hydroxide causes rapid decomposition. Organic and inorganic liquids containing water reduce transverse strength but in all tests thus far, specimens maintained their original dimensions.

Boron nitride *bonded with silicon nitride offers another field of investigation.*

Electrical characteristics

The resemblance between boron nitride and graphite ends when electrical characteristics are considered. Resistivity of boron nitride approximates that of electrical porcelain at low and moderate temperatures, but high temperatures affect these values. At 1800 F resistivity of boron nitride is 3.1×10^4 as compared with 1.7×10^{13} at 75 F.

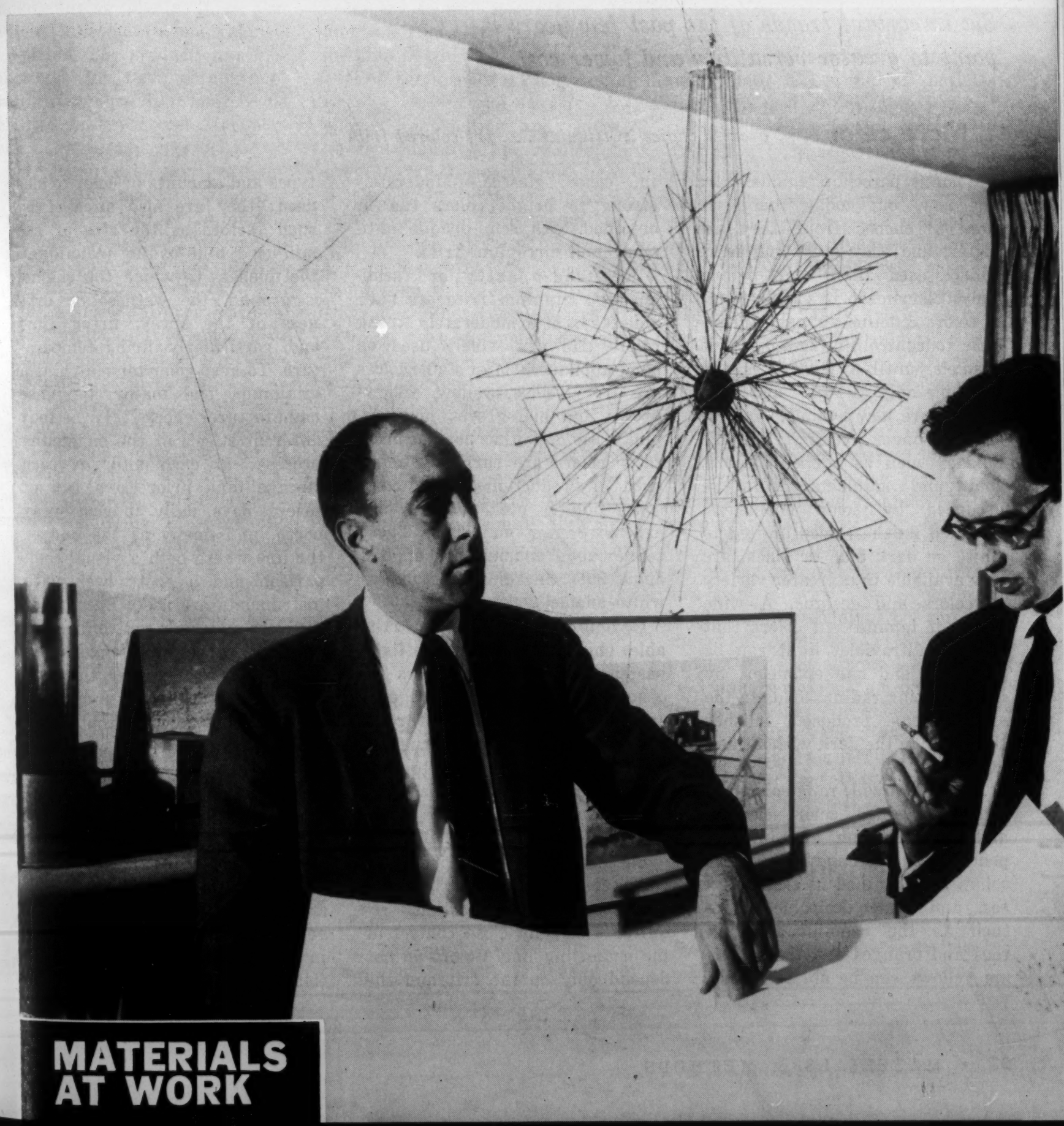
Measured parallel to pressing force and at room temperature, dielectric constant of the material is 4.15 at frequencies from 100 cycles to 100 megacycles per second. Perpendicular to pressing force, dielectric constant is 4.80. These values change only slightly at temperatures up to 1000 F.



The chandelier shown below consists of nickel rod and tube which carries electricity to 192 tiny light bulbs, eliminating the need for wiring. A similar but larger one was installed in the lobby of the Barbizon-Plaza Hotel, New York. The fixture was designed by Richard Kelly and fabricated by Edison Price, Inc.

It consists of a vertical, seven-foot length of 5/8-in. dia nickel rod, one end of which connects to the power supply in the ceiling, the other to a 2¾-in. dia bronze ball. Radiating outward from the ball are 24 lead tubes, to which are welded at irregular intervals four pieces of 5/16-in. dia nickel tubes. Nickel-plated brass fittings in the ends of these 5/16-in. tubes house the tiny light bulbs.

Nickel tube forms wireless light



MATERIALS AT WORK

by John B. Campbell,
Associate Editor,
Materials & Methods

***Porcelain-enameled** aluminum ceiling panels save weight, reduce maintenance in New York City's new subway cars.*
(N. Y. Transit Authority)

What's New in Porcelain Enamel?

Six important trends of the past few years point to greater versatility and lower cost.

1. More color *. . . greater choice in titanias . . . pre-colored frits*

Colored porcelain enamels are not new, but today there are more to choose from, they are better, and they are being more widely used than ever before. Only the crimson to purple range of colors remains virtually impossible to control. Titania-opacified enamels, until a few years ago available only in white and light pastels, are now available in several stronger colors. Metallic finishes such as copper, bronze, gold and gunmetal can be produced by some enamelers. Speckled finishes, once limited to white on dark blue or black, are now available in a greater variety of colors and designs. A wide range of luminescent colors that glow in ultraviolet light can be produced, and one enameler, by incorporating radium oxide in the enamel, has produced finishes that glow in the dark without any excitation.

Although a wide range of colors can be obtained, color selection and frit selection are interdependent. The strongest, brightest colors are obtained in clear glasses, and some desirable colors such as the cadmium-selenium reds and oranges and the cadmium yellows can be obtained only in clear glasses. Moderately strong to bright colors can be obtained with semi-opaque antimony and zirconium frits.

Reduced-opacity or "semi-opaque" titanium frits are suitable for light to moderately strong colors and are widely used on home appliances. Most stable colors are ivory-yellow, yellow, yellow-brown and blue-green; however, pink, gray and other popular decorator colors are currently being used in production even though some, notably pink, require very expensive raw materials. These semi-opaque enamels are applied about 20% thicker than standard white enamels.

Opaque titanium frits are suitable chiefly for weak or light pastel colors. Strong colors in opaque titanium enamels require such a high proportion of color oxides that the enamels must be ground finer than usual to prevent speckling, and it is hard to satisfactorily adjust the working properties of such enamels.

Successful use of colored porcelain enamels, particularly where color match is important, requires unusually close control of the enameling line. Colors do not depend only on the frit and the types and amounts of color oxides used; they are also affected by such factors as the size of the mill used, mill loading techniques, the fineness to which the enamel is ground, the wetness or dryness of the spray, firing time and, particularly, firing temperature. To keep color mismatch at a minimum, one major appliance manufacturer checks color at four different stages of the enameling process: at each mill, at each storage tank prior to a run of several days, daily at each spray booth, and finally at the end of the line where both a visual comparison and a spot check with instruments are used. Because of the close materials control needed, overspray of colored enamels is usually scrapped rather than recirculated. Adding to production problems is the fact that some defects that might be acceptable in white enamels seem to be highlighted in glossy colored enamels.

Some color matching problems have been alleviated by new smelted-in colors. Previously limited mainly to intense blues and blacks, pre-colored frits are now available in blue-green and in several lighter colors. These frits not only simplify color con-

trol but also make it possible to repair defects by spot patching rather than by recoating the entire surface as many colored enamels require. Since these colors cannot be altered quickly to meet changing demands and the number of different colors available is still quite limited, smelted-in colors are useful primarily for parts produced in large volumes.

2. Modern production *. . . continuous conveyors . . . automatic spraying, dipping*

Continuous production lines utilizing conveyors and automatic methods of applying the slip are becoming increasingly common in the enameling industry. On some new lines parts are cleaned, pickled or sand blasted, coated, dried and fired without any manual handling at all. Although the trend has been more pronounced in the large-volume appliance manufacturing plants, it is also evident in some custom enameling plants. The production economies resulting from greater mechanization should ultimately be reflected in lower costs for porcelain enamel coatings.

An important part of the trend toward mechanization has been greater use of automatic spraying. Compared to manual spraying, automatic spraying not only cuts labor costs but also produces more uniform coatings, thereby reducing the amount of enamel needed to insure a specified minimum thickness.

A refinement of automatic spraying, electrostatic spraying, has been adopted by a number of enamelers. Chief advantage of the electrostatic technique is a marked reduction in overspray. Whereas ordinary spraying usually gets less than 50% and sometimes as little as 5% of the enamel on the part, electrostatic spraying is about 75 to 80% efficient. Although the increase in spraying efficiency may not be too important where overspray can be recirculated, it may produce significant materials savings where expensive colored enamels are being applied.

However, electrostatic spraying has not proved to be as simple and effective for porcelain enamel as it has for organic finishes. Generally, electrostatic spraying requires closer control of both the enamel and the spray booth atmosphere than is customary in most enameling plants. For example, because of the relatively high density of the enamel it is necessary to mill it considerably finer than usual to keep the momentum of the charged particles within the proper range; as a result, careful adjustment of enamel composition and atmospheric humidity are needed to prevent the formation of hairline cracks in the bisque. In addition, some kind of air conditioning or special atmosphere is needed to prevent airborne contamination of the enamel. Despite these and other complications, it is likely that electrostatic spraying will become more and more widely adopted.

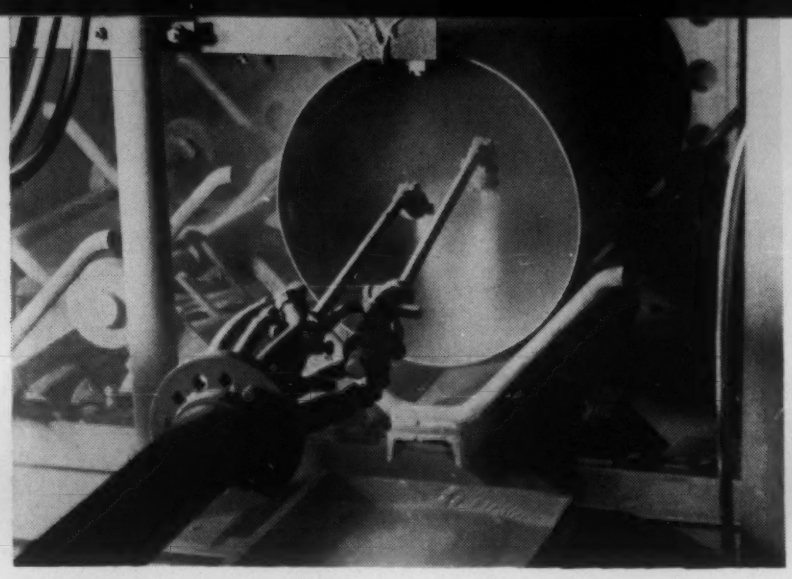
Unlike spraying, which lends itself readily to mechanization, dipping has remained pretty much a hand operation. Within the past few months, however, a unique installation at General Electric's refrigerator plant has shown that dipping, too, can be successfully mechanized. A completely automatic dipping machine, one of the first of its kind in the enameling industry, is used to apply a ground and a cover coat to both sides of a vegetable pan. Each pan is automatically grasped by tongs, lowered into the tank, rotated through the slip, withdrawn from the tank, and rotated again to avoid single-point drain; finally the tongs are bumped to dislodge excess enamel, thereby eliminating the need for beaded or cupped edges in the pan design (a light spray is used to reinforce the cover coat at the edges). This automatic dipping operation has been fully integrated with a continuous production line.

Like automatic spraying, dipping produces uniform coatings and, where a coating on both sides of a part is desirable, with virtually no waste of enamel. Even if a part needs enamel on only one side, coating both sides by dipping may require no more enamel than coating one side by manual spraying. Since a complex part can be dipped far more easily than it can be automatically sprayed, it is plain that the mechanization of dipping extends the range of applications where high-production economies can be achieved.

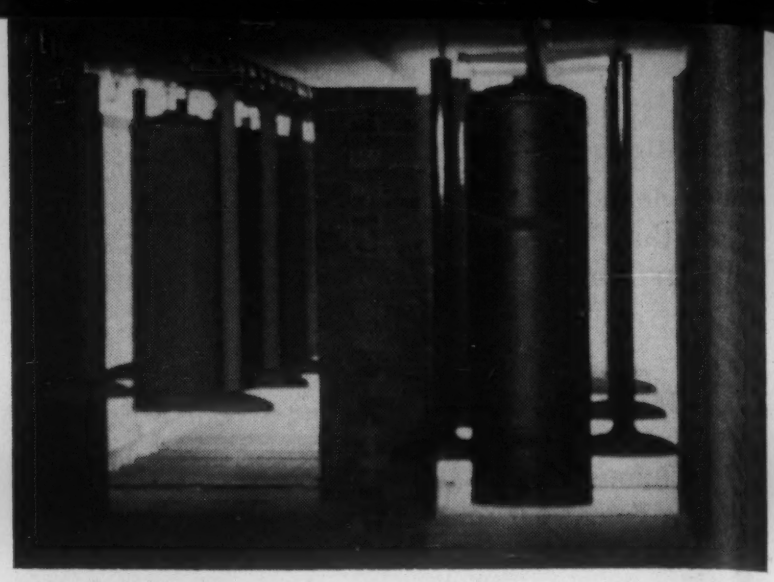
Another cost-cutting coating method that has received more attention lately is flow-coating. Limited to simple shapes, the method seems particularly advantageous for large cylindrical parts; for example, A. O. Smith flow-coats its water heater shells and flues. The technique has some important limitations: Working properties of the slip must be controlled more closely than in spraying or dipping; the enamel does not wet steel as readily as in other methods; the coating is thinner at the top; and the coating is prone to drain streaks.

3. Better chemical resistance *. . . hot water, alkalies . . home water heater*

Porcelain enamels have always had good chemical resistance; but both the range and the complexity of service conditions which they can meet successfully have been continuously extended to keep up with product changes and new applications. For example, modern washing machines and



Spraying *a heater shell*



Firing *shells and flues*

How Rheem makes a "glass-lined" hot water tank

A pre-cut steel sheet is roll formed and welded to make a cylinder, then welded to a tank head. A flue and bottom sub-assembly is similarly formed. The tank is designed so that surfaces to be enameled intersect at angles well over 90 deg, and shell and bottom head are flanged outward to provide a tight fit in final assembly. All welds are made automatically by the metallic submerged arc method, then ground smooth. After a pressure test, the sub-assemblies are cleaned and neutralized, air dried, and blasted with carbon steel chips; a specially developed blue ground coat enamel is then automatically sprayed on the exterior of the flue and the interior of the shell

synthetic detergents have made it necessary to develop enamels with better resistance to both hot water and hot alkaline solutions. Probably the most challenging new application, however, has been the domestic hot water heater.

Pioneered by A. O. Smith, the "glass-lined" water heater was relatively unsuccessful until a few years ago when a magnesium anode was incorporated in the design to provide cathodic protection for incompletely coated welds and other metal areas bared by pinholes or other defects in the coating. Enameled heaters are now made by many manufacturers.

The service conditions encountered in a hot water heater shell are complex and severe. The porcelain enamel coating must withstand continuous immersion in water that, though nominally limited to a temperature of 160 F, may actually be hotter than 170 F near the top of the shell. The water is under pressure and, depending upon the locality, may be either acidic or alkaline. Furthermore, the enamel must be applied to shell and flue sub-assemblies that have been made from non-premium hot rolled steel and assembled by welding.

The success achieved in this application can be measured by the strong competitive position of glass-lined heaters today. Although not considered equal to the more expensive copper- or monel-lined heaters, glass-lined heaters carry 10-yr guarantees and command a premium over galvanized heaters where aggressive waters are encountered.

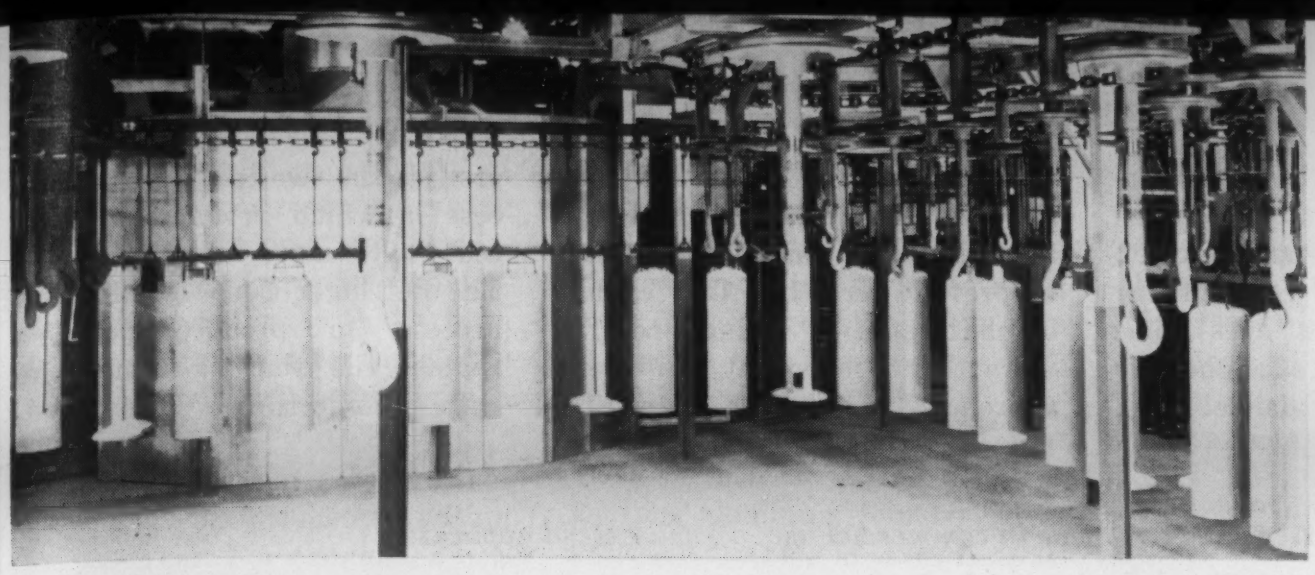
Inevitably, specifications for chemical resistance have not always kept up with new applications. There are no industry-wide standard tests for resistance to hot water or alkalies, let alone agreement on the proper criteria for enamels in certain important applications, particularly the water heater. However, these problems are well recognized and are receiving considerable attention in the enameling industry. Current work indicates that an alkali resistance test now being widely used—immersion in boiling 5% tetra sodium pyrophosphate—may soon be officially accepted as a standard.

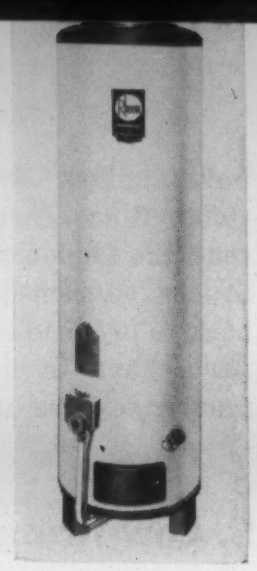
4. Thinner coatings ... *new enameling steel ... a promising metal treatment*

Ever since the advent of the highly opaque titanium enamels, the enameling industry has been trying to find a way to fire a cover coat directly on iron or steel without any sacrifice in the quality of the finish. Thin coatings, though less impact-resistant, withstand torsional damage better than thick coatings. They also require less material and fewer production steps.

Changes in enamel formulation alone have not been very successful. Ground coats have been modified to give a wider range of dark colors and some attractive self-mottling finishes, Some one-coat white and light-colored enamels have been developed, but they have not been comparable to conventional enamels. Of greatest commercial importance is the new low-firing Porcenell enamel (see "low-firing enamels").

By far the most successful one-coat enameling has been done with Ti-Namel, a specially stabilized premium steel marketed by Inland Steel Co. Ti-Namel not only eliminates reboil, but also has two to three times the sag resistance of enameling iron. Because of its high price—about $55 per ton more than enameling iron—and its limited supply, Ti-Nam-





***Continuous** conveyors speed production*

(a light dust coat is applied to the shell exterior to prevent scaling). The enamel is dried, and the bisque brushed back from areas to be welded. This entire sequence, from cleaning to brushing back, occurs on a continuous conveyor line. The parts are manually transferred to the furnace conveyor, shell and flue alternately to minimize variations in any one tank, and fired at 1600 F. After visual inspection, the parts are tapped for fittings, then assembled with the aid of a hydraulic ram. Shell, bottom head and a separate skirt ring are welded together automatically; flue and top head are welded together manually. The entire assembly is given another pressure test and is then ready to be fitted with jacket, connections and controls. The enameling process, from cleaning tank to the second pressure test, takes just about 1¾ hr.

---

el has been used only for critical applications, such as range tops. Many enamelers agree that Ti-Namel would be more widely used, despite its high cost, if it were available in larger quantities; however, there is no immediate prospect of a change in either price or supply.

Meanwhile a new material for one-coat, one-fire enameling is reportedly being field tested by Armco Steel Corp. Although the company has made no announcement, it is believed that the new steel will cost more than regular enameling iron but less than Ti-Namel, and that it will not equal Ti-Namel in sag resistance. Enamelers who have tried the material say that it is "promising" but that, at least so far, it does not seem to be the final answer to the one-coat problem.

In the past, several attempts have been made to develop a special metal surface treatment that would permit one-coat enameling. Most attempts, such as annealing after the nickel dip, have been largely unsuccessful, although one method, Strong Manufacturing's Ti-Loc Process, was used commercially for lamp reflectors prior to the demise of the company a few years ago. The Ferro-Republic process, which utilizes deep etching or blasting followed by electroless nickel plating, is still being studied by some enamelers but is not yet being used commercially to any important extent. Although the more uniform nickel film improves adherence, it does not seem to eliminate black specking in one coat.

The latest and most promising metal treatment is the Parker Pre-Namel 410 process. Developed by Parker Rust Proof and tested in cooperation with Pemco and Frigidaire, the process utilizes an iron phosphate coating that is pre-fired at enameling temperatures to produce a uniform iron oxide film on the metal surface. Some enamelers who are studying the process say the iron oxide film seems to virtually eliminate reboil; as a result, they believe that one-coat enamels on non-premium steels may soon be commercially feasible. Potential savings over conventional two-coat enameling are said to be considerable. Frigidaire, which has already set up a pilot line, reports that the finish obtained is satisfactory for some purposes, but that further work will be needed to determine whether it will be satisfactory for all applications. The enamel being used by Frigidaire is a blend of two titania-opacified frits and is fired at about 1480 F.

According to Parker, a one-coat enamel applied by the new process shows adherence markedly superior to that of conventional two-coat enamels on both enameling iron and cold rolled steel; has a torsion value of 200 deg (5.4-mil coat) compared to 70-100 deg for a conventional coating (7½ mils); resists fishscaling in an accelerated test from two to five times as long as a conventional coating; and is superior to a conventional coating in resistance to pinpoint rusting. Since the oxide coating is sufficient to prevent scaling during firing and shows good rust resistance in humidity and salt spray tests, it may be possible to omit the back side enamel for some applications.

Certain precautions are necessary to insure proper oxide formation. Careful cleaning is essential. A deionized water rinse is necessary after phosphate coating. It appears that both water and mill additions must be free of chlorides. All handling equipment must be free of lead. Pre-fire time is critical. Neither the phosphate nor the oxide film may be exposed to fumes; e.g., pre-firing and enameling cannot be done together in the same furnace.

One-coat enamels, no matter

how applied, have some limitations. Since there is no ground coat, the tendency toward burn-off cannot be remedied by brushing back to produce black edges; some parts have to be redesigned so that edges are not visible. Also, experience with Ti-Namel has shown that unusually careful handling of the metal is required to prevent scratches that cannot be obliterated by a single coat.

Another somewhat different approach to reducing enameling costs is the two-coat, one-fire process in which ground and cover coats are fired simultaneously. The Bettinger Corp. is using this process to produce porcelain enamel tile that is competitive with ceramic tile.

5. Low-firing enamels *. . . now in commercial use . . . will extend applications*

Low-firing enamels, i.e., enamels that mature below 1350 F, seem to be on the threshold of commercial acceptance. Low firing temperatures have many advantages: less warpage, making possible thinner gages; less reboil, eliminating many common surface defects; and lower fuel, tooling and maintenance costs. The object of recent development has been enamels that are not only silica-free but also lead-free. Among the most promising materials are the phosphate glasses, containing large amounts of phosphoric, boric and aluminum oxides.

In general, the low-firing enamels that have been developed so far do not measure up to standard commercial enamels, particularly in chemical resistance and abrasion resistance. Although these enamels will undoubtedly prove satisfactory for some of the less demanding uses of present enamels, most enamelers feel that their principal effect will be to extend the use of porcelain enamels to applications for which they have previously been too expensive. Such applications might include some now served by organic coatings, but to a great extent they would be applications where organic coatings lack sufficient durability—an area now served in many cases by metallic coatings and corrosion-resistant metals and alloys. Low-firing enamels have already been used on pipe and transformers; other applications that have been suggested include roofing, garbage cans, window sashes and light bulb brackets.

One company, Benjamin Electric, is using low-firing enamels for chalkboard panels and for corrugated panels designed for industrial exteriors. These lead-free enamels, including one that has been trade-named "Porcenell", were developed by Vitreco, Inc., a research company owned jointly by Poor & Co. and Youngstown Sheet & Tube Co. Firing temperatures are generally about 1250 F. Both alkali-resistant and AA acid resistant enamels are available, and high resistance to thermal shock is claimed. Since adherence is obtained without the use of nickel or cobalt in the enamel, a free choice of color in the ground coat is possible. It is claimed that these enamels do not burn off edges and corners, that no warping occurs, and that there is no boiling over weld areas; as a result, these enamels seem to be well adapted to designs previously suitable only for organic coatings. Benjamin Electric's coatings are being applied to 20- and 22-gage sheet in one or two coats for a total thickness of 2-4 mils. In most cases metal preparation is conventional.

6. New base metals *. . . use of aluminum grows . . . interest in stainless*

Use of porcelain enameled aluminum is expanding rapidly, but primarily within the architectural and transportation field where its light weight, its workability and its resistance to edge corrosion are particularly important. The future of this material in other applications depends considerably on the extent to which its cost can be reduced and, to a lesser degree, on the extent to which certain of its properties can be improved.

At the present time, for example, it does not look as though porcelain enameled aluminum will soon be used in major appliances to any important extent; designers seem to be wary not only because of its higher cost but also because its lower strength would necessitate considerable redesign. On the other hand, it is conceivable that enameled aluminum, because it can be cut without spalling after enameling, may be useful for some parts where production flexibility is desirable, e.g., where model changes are frequent.

A more likely base metal than aluminum for structural applications where light weight is not too important is aluminized steel. This material, coated with a modified aluminum enamel, combines the strength, rigidity and sag resistance of steel with much of the workability and corrosion resistance of enameled aluminum. No chromate surface treatment is required; metal preparation consists simply of cleaning. General Ceramic is enameling aluminized steel for chalkboard panels.

The technical and economic position of enameled aluminum continues to change rapidly as enamelers become more familiar with the process and as new materials and techniques emerge from the laboratory. Whereas it has been customary in the past to use a ground coat, i.e., a coat

containing minimum amounts of opacifier and coloring oxides, the ground coat has now been eliminated in a majority of applications; it is estimated that within a year virtually all enamels on aluminum will consist of only a single coat.

There have been several other promising developments within the past year. For example, a new and simpler pretreatment for aluminum alloys has been developed by Alcoa. Known as the "Alcoa R-100 Process", it consists of immersion in an inhibited acid bath (a hot chromic-sulfuric acid solution), followed by water rinsing and drying. Unlike the present alkaline chromate treatment, this new process requires no pre-fire and does not build up hard-to-remove reaction products on the metal surface. According to Alcoa, spall tests show the new treatment is just as effective as the present treatment.

Ferro has developed an improved and less expensive mill addition. The present mill addition agent, a sticky liquid, is replaced by an approximately 50:50 blend of two dry powders, sodium meta silicate and boric acid. The new agent not only makes it easier to adjust the working properties of the enamel, but also seems to provide somewhat higher gloss and equal or better chemical and abrasion resistance compared to conventional aluminum enamels. The new agent is almost ten times cheaper than the present one.

Although lead-free enamels developed so far have been generally inferior to leaded enamels, it seems probable that good lead-free coatings will eventually be developed. A new lead-free frit announced recently by Minnesota Mining & Manufacturing is now undergoing field tests, but no details are available. Actually, those familiar with the leaded frits say that because of their limited solubility they are not toxic, and that present restrictions on their use are more a matter of good public relations rather than of scientific caution.

Enameling of aluminum castings has generally been avoided wherever possible because it has been difficult to obtain castings in which both composition and porosity were sufficiently controlled. These are problems that must be solved in the foundry, and one aluminum foundry, Monarch Aluminum, is now successfully producing enameled permanent mold castings on a regular commercial basis. Earliest uses include cookware made by Club Aluminum Products Co. and by General Electric's Small Appliance Division (enamel is applied only to exterior surfaces). Still greater porosity problems will have to be overcome, however, before enameling of aluminum die castings becomes commercially feasible.

An intriguing, though as yet unexploited, material has been developed by Ferro. It consists of continuous 0.005-in. aluminum sheet with a 3-mil coating of porcelain enamel on one or both sides. The foil, easily cut with household scissors, can be produced in a wide range of glossy or matte colors, and it may be obtained flat, embossed or corrugated. The process is currently limited to 1100 and 3003 alloys, but it will probably be extended to other alloys and to thicker foil.

Much interest has been shown lately in enameled stainless steel, particularly for architectural uses. Enameled stainless would provide a permanent, durable color on a non-corroding base metal. Unlike aluminum, stainless enameled on only one side does not require straightening after firing at 1000 F, the maturation temperature of current enamels. If the entire surface is coated, it might be possible to use less expensive Type 430 instead of 302 for outdoor exposures. Small flaws not visually objectionable could be ignored without fear that they would become focal points for corrosion and spalling. A Princeton study recommends the use of clear or semi-opaque enamels that would allow some of the metallic quality to show through, and suggests that enamels applied discontinuously to either flat or textured sheet might be particularly effective. It seems likely that enameled stainless will also be considered for other applications, e.g. automotive trim.

Acknowledgment

The author wishes to acknowledge with appreciation the help of the following organizations in the preparation of this article:

Allied Porcenell, Inc., Armco Steel Corp., The Bettinger Corp., Chicago Vitreous Corp., E. I. du Pont de Nemours & Co., Inc., Ferro Corp., General Electric Co. (Major Appliance Div.), Inland Steel Co., Parker Rust Proof Co., Pemco Corp., Rheem Mfg. Co., Westinghouse Electric Corp. (Electric Appliance Div.).

References

Extensive use was made of papers published in *Proceedings of the Porcelain Enamel Institute Forum*, vol. 16, 1954, and papers to appear shortly in the *Proceedings*, vol. 17, 1955. Other references:

"Automation at G.E. Cuts Costs, Improves Quality", *Ceramic Industry*, vol. 65, Sept 1955, p. 50-2.

Bricker, B. C., "Why Porcelain-Enamel Aluminum", MATERIALS & METHODS, vol. 40, Sept, 1954, p. 107.

"Curtain Walls of Stainless Steel", a study prepared for the Committee of Stainless Steel Producers, American Iron and Steel Institute, by the School of Architecture, Princeton University, June 1955.

Goetchius, D. R., "Porcelain Enameled Aluminum . . .", *Ceramic Industry*, vol. 62, Apr 1954, p. 159, 161, and May 1954, p. 72-3, 103.

Hommel, E. M., "Developments in Vitreous Enamelling on Steel in the U.S.", *Foundry Trade Journal*, vol. 96, Jan 7, 1954, p. 19-24.

Huppert, Paul A., "Porcelain Enameled Chalkboard", *Ceramic Age*, vol. 65, Mar 1955, p. 15-19.

"Low Temperature Ceramic Coatings for Light Gage Metal", *Finish*, vol. 12, Sept 1955, p. 36-9, 93-4.

Nelson, F. W., "Flow Coat Applications of Porcelain Enamel", *Proceedings of the Porcelain Enamel Institute Forum*, vol. 15, 1953, p. 120-4.

Nikleuski, B. K., "Silica-Free Enamels", *Sheet Metal Industries*, vol. 29, Nov 1952, p. 1037-8, 40.

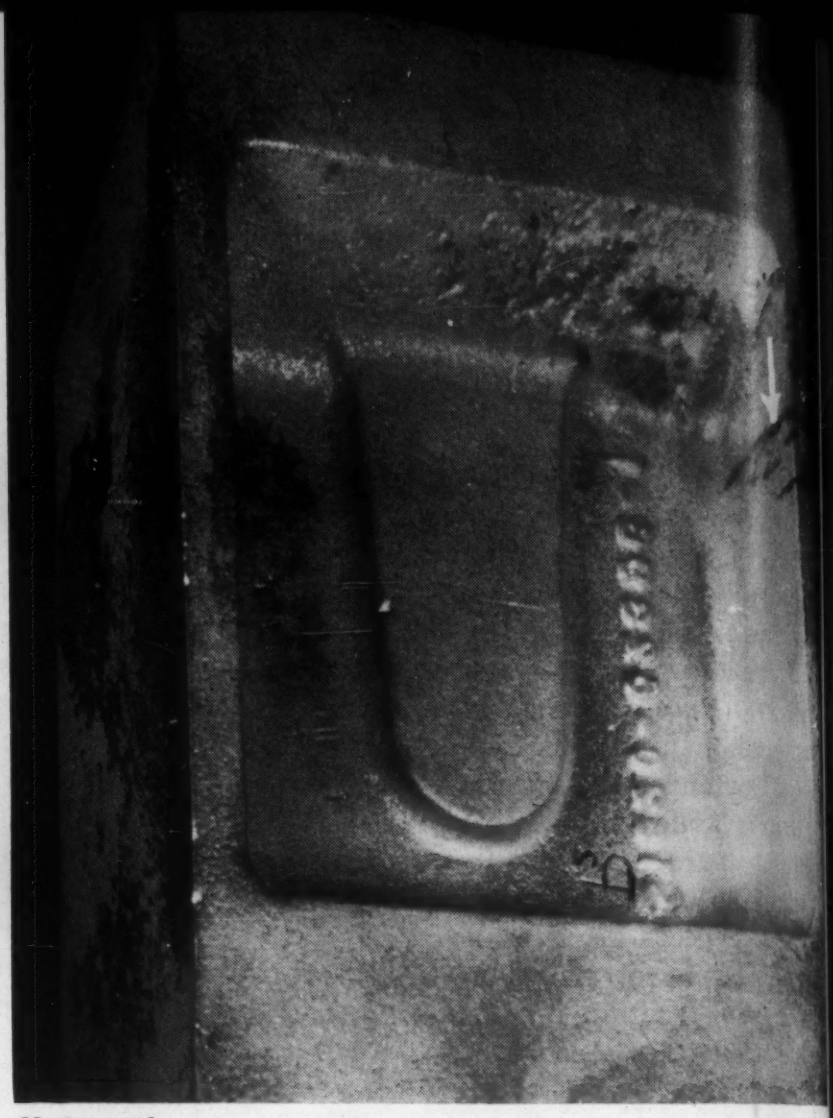
O'Keefe, Philip, "New Developments in Porcelain and Ceramic Coatings", MATERIALS & METHODS, vol. 35, May 1952, p. 87-9.

Porter, Frank R., "Fabrication and Enameling Performance of Titanium Enameling Steel", *The Bulletin of the American Ceramic Society*, vol. 25, July 15, 1946, p. 259-66.

Sweo, B. J., "Porcelain Enamel Article and Method of Producing Same", U.S. Pat. No. 2,581,310, Jan 1, 1952.

Zick, B., "The Direct Application of Finish Coat Enamels to Sheet Steel. General Considerations", *Sheet Metal Industries*, vol. 31, Nov 1954, p. 939-45.

Oxide skin



Hot crack

These flaws detected with

New Nondestructive Test

New method developed at Sikorsky is used also by several other foundries with satisfactory results.

by G. R. VanDuzee, *Senior Materials Engineer, Sikorsky Aircraft Div.*

■ The use of magnesium alloy castings at high stress levels necessitates nondestructive testing procedures to indicate casting quality. Among these procedures, government aircraft requirements include the use of penetrant inspection on certain classes of nonferromagnetic alloys. Commonly penetrant inspection methods depend on the use of a fluorescent material.

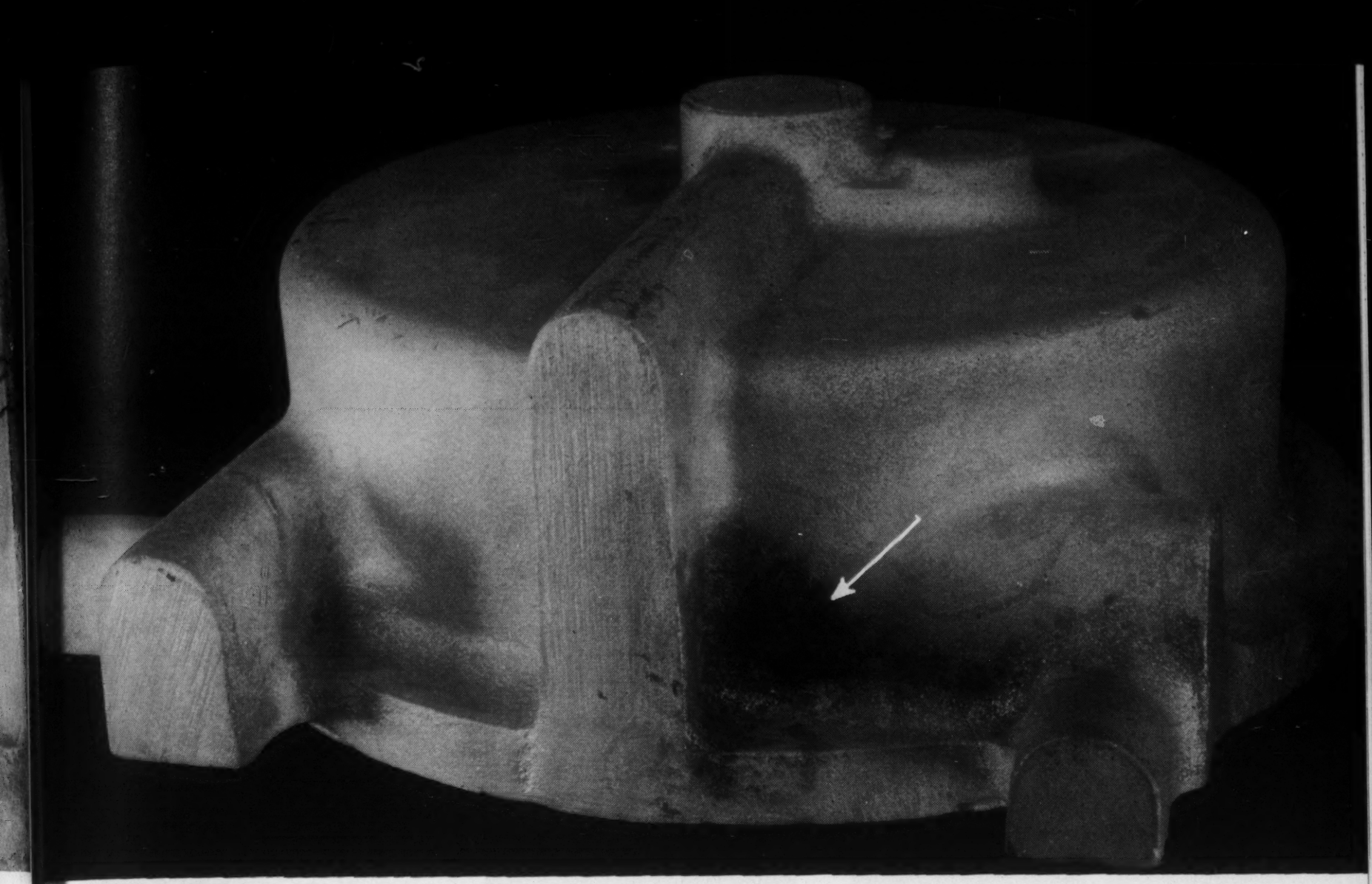
Fluorescent penetrant is quite satisfactory in locating defects in some castings but has certain undesirable features. These include 1) use of special lighting conditions, 2) effect of surface condition of casting and rinsing on retention of penetrant, 3) smearing of penetrant during handling, 4) uncertainty that surface has been inspected completely because of casting contours, 5) observation of internal surfaces difficult because of use of near-ultraviolet light and 6) absorption of penetrant by foreign materials on the surface leading to false indications.

To overcome the disadvantages of the fluorescent method, one user of magnesium castings has developed a different procedure. This is based on bleed-out of penetrant and is similar to the procedure used successfully for indicating surface defects on anodized aluminum.

Although various combinations of chemicals and procedures can be used, the following method has produced dependable results with the least difficulty in application.

The casting is treated in a solution containing 5% by volume of 66 deg Bé sulfuric acid for sufficient time to remove about 0.004 in. from the surface and rinsed in cold water. The surface is then cleaned by immersion for 2 min in a bath containing 15% by weight of hydrofluoric acid and rinsed again in cold water. At this stage, the surface is clean and silvery in appearance. The casting is then immersed for 3 min in a bath containing 5 lb of chromic acid and 38 ml of nitric acid per gallon, given a cold water rinse followed by a hot water rinse and is ready for inspection.

After treatment, surface de-



Microshrinkage

for Magnesium Alloy Castings

fects are indicated by the bleeding of chromic acid to produce an amber stain against the silvery background. All defects common to the surface of magnesium alloy castings are readily found by this procedure. Examples are given in accompanying illustrations. These include an oxide skin and an area of microshrinkage. The process has even permitted the location of cracks which had been missed in fluorescent penetrant inspection. The surface indications are evaluated by the procedures used with fluorescent methods.

Advantages of the new procedure over fluorescent penetration methods are:

1. A surface defect is indicated by a stain visible under ordinary lighting conditions, thus lessening the possibility surface areas will be missed.

2. The etching action provides uniform surface with no retention of penetrant except in defective areas.

3. Smearing due to handling is not a factor since bleed-out produces a permanent stain.

4. The silvery background of the casting and the contrast of stains in defective areas permits easier examination of internal surfaces.

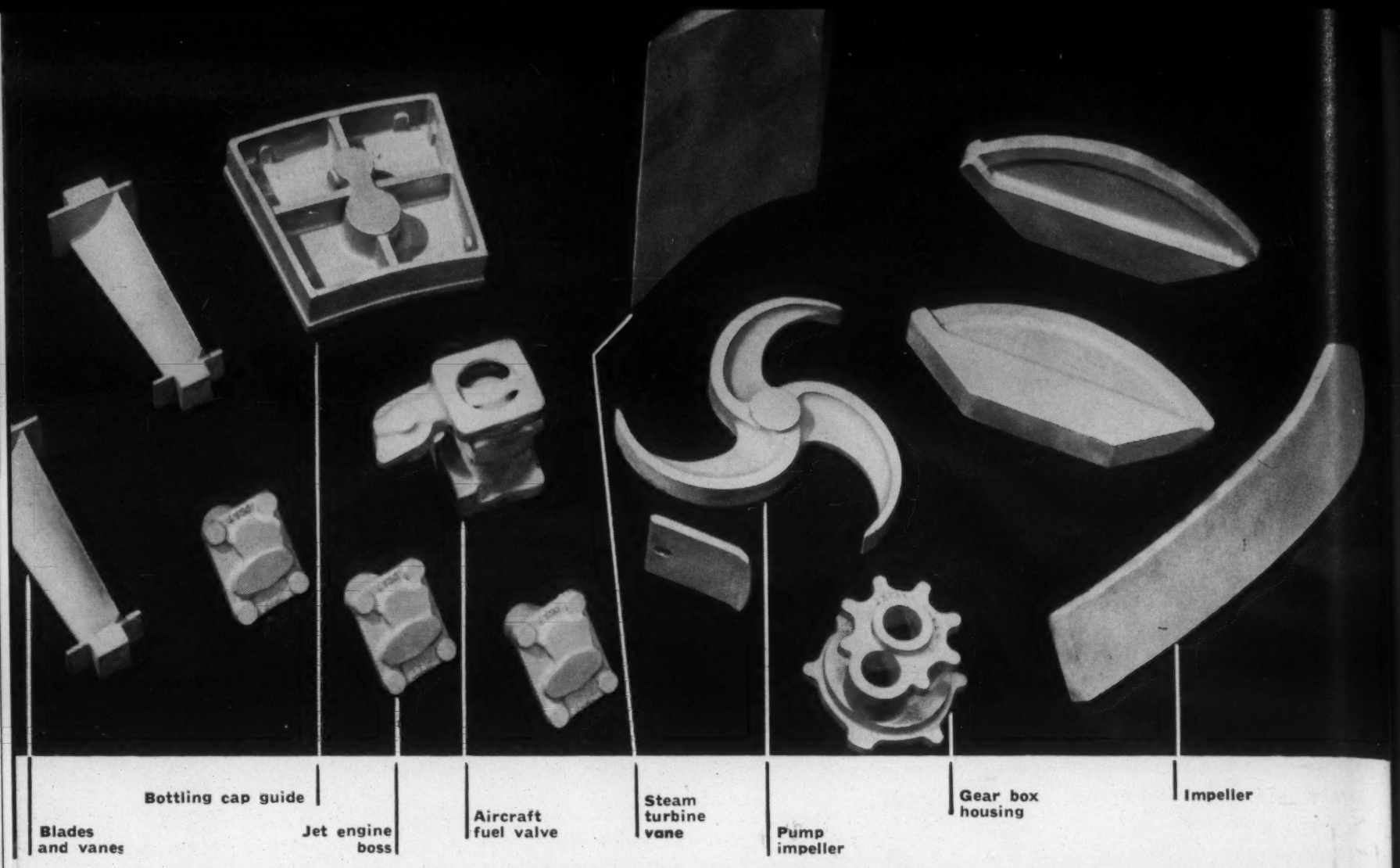
5. The chemical action of the process removes foreign materials on the surface and eliminates false indications from that source.

6. The surface coloration and lighting conditions minimize operator eye-strain and increase dependability of the inspection.

In addition to the advantages listed, it has been found that some superficial flaws shown by fluorescent penetrant methods are eliminated by the removal of 0.004 in. from the surface, thus avoiding the necessity of grinding them out.

Although this inspection method can be used satisfactorily on most raw castings, there are objections in certain instances. When castings are produced by a method designed to give a smoother surface than sand casting, the etch inspection should not be used unless the etched surface produced is acceptable. Dimensional tolerances must also be considered since the procedure will remove approximately 0.010 in. from the section thickness.

Any inspection procedure, to be of the utmost value, should be applied as soon as possible to avoid building up costs on a defective part. The new inspection procedure can and should be applied at the foundry so that personnel responsible for producing castings can see the casting flaws and make appropriate changes in foundry practice to eliminate them.



These are typical uses of

Ceramic Mold Steel Castings

by Edward Vogel, *Research Engineer, Lebanon Steel Foundry*

What They Are

■ Ceramic mold casting, developed in England as the Shaw Process, has been applied to the production of steel castings by Lebanon under the name Ceramicast.[1] The new process is an investment casting process but does not use expendable patterns and, thus, differs from the lost wax and mercury processes.

Castings of carbon and low alloy steels, chromium and chromium-nickel corrosion and heat resisting steels and cobalt-base superalloys, can be made by the process. Although Lebanon does not produce nonferrous alloys, with the exception of the superalloys, ceramic mold casting can be used for casting aluminum alloys, brasses and bronzes and similar materials.

[1] *Produced under licensing agreement with Shaw Processes, Ltd.*

What Industries Are Using Them

Successful castings are being produced to the exacting requirements of the aircraft industry, the atomic energy program, the chemical industry, the bottling industry, and for prototype work in the field of gas turbine vehicular propulsion.

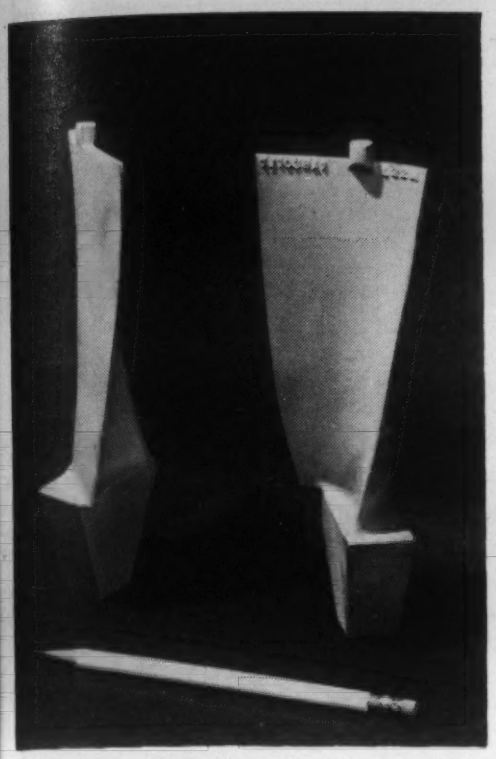
For service in the aircraft field, jet engine manifolds and blades have been produced from highly alloyed materials while bearing supports and elbows have been cast from low alloy steels. Other aircraft components include landing gear struts, shock absorber housings, brake backing plates and certain structural elements where it is possible to use ferrous alloys.

Engine applications include also blades and vanes for gas turbine vehicular propulsion, steam turbine guide vanes and diesel engine heads, the latter produced from heat resisting alloys.

There have also been a variety of industrial applications. These include stainless steel pump impellers and filter press frames produced for service in the process industries, bottling cap guides, and drop forging dies. Among large parts which have been produced are chromium steel glass molds for 21-in. television tubes. These weigh as much as 300 lb.

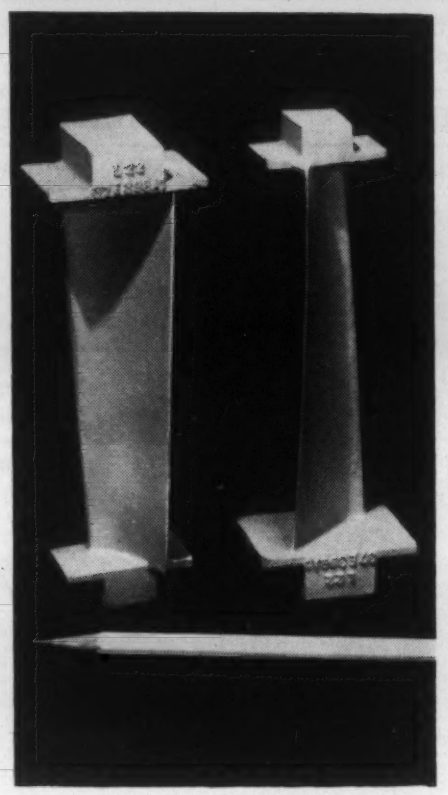
Extrusion die inserts of a cobalt base alloy have been highly successful in the extrusion of copper, the highly alloyed inserts have served for the extrusion of more than 2000 billets, compared with a previous limit of about 250 billets with stainless steel. Dies of chromium steel produced for plastics injection molding have also given excellent results.

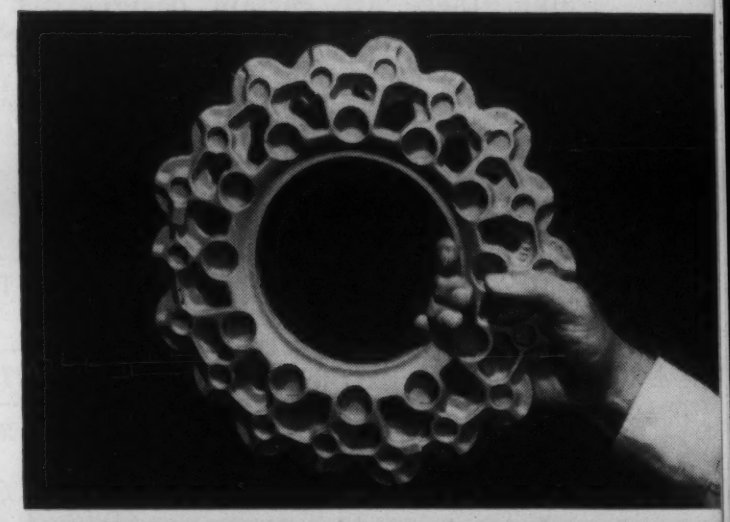
Ceramicast Parts Have These Advantages . . .

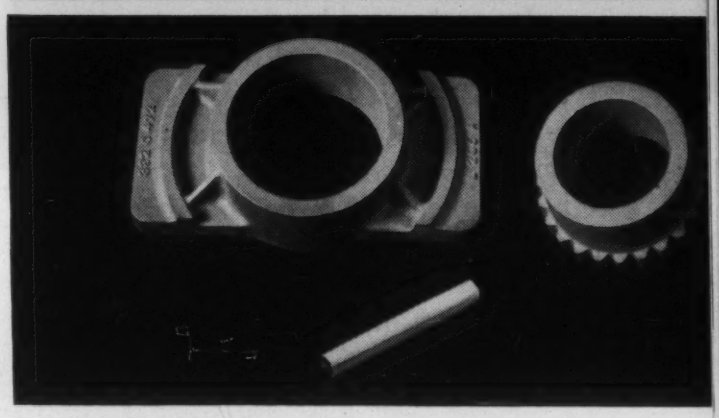


Knife-like edges *indicate the detail which can be obtained on (a) blades for a land gas turbine (left) and (b) vanes for a land gas turbine.*

***Intricate designs** are obtainable. Typical is this backing plate for a jet aircraft brake system.*







Smooth surfaces *can be produced. On this jet engine bearing housing (left), no machining was necessary.*

A qualitative comparison of ceramic mold castings with precision investment castings, sand castings and shell mold castings is given in a table. Ceramic molding has certain significant advantages over each of them for producing castings of medium or small size.

The ceramic mold process uses a split mold, allowing the use of patterns which are no more expensive than those used for sand casting. On the other hand, patterns for precision mold castings are considerably higher in cost. The new process permits the production of small quantities of prototype parts within a few hours after the original is received, making the process highly advantageous in component development. After the proper design has been determined, regular wood or metal patterns can be prepared for production runs.

Design complexity far exceeding that possible with conventional sand castings is possible, and sections as thin as 1/16 in. can be cast over a wide range of sizes up to weights of more than a hundred pounds.

Tolerances obtainable with ceramic mold castings are far closer than those obtainable on sand castings. Within one-half the mold, tolerances of ± 0.003 to ± 0.005 in. can be maintained. These figures compare favorably with those usually specified for precision castings produced by the lost wax or mercury processes. However, the lost wax and mercury processes have an advantage since a one piece mold is used. Because a two piece mold is employed in the ceramic mold process, greater tolerances are required across the parting line. These range from about ± 0.006 to ± 0.010 in.

Surface smoothness on ceramic mold parts is far superior to that obtainable on sand cast parts, but is not quite so good as that resulting from casting in a mold prepared by the lost wax or mercury processes. However, the combination of finish and dimensional tolerances is such that machining can be eliminated or reduced.

. . . and These Limitations

While the new process has many significant advantages, it also has inherent limitations, and the design and materials engineer must carefully evaluate these limitations to make the best possible use of the process. Accuracies possible by the ceramic mold process are subject to qualification. It has been the experience at Lebanon that the dimensional history of the Ceramicast part is competitive with the lost pattern type in some cases and definitely noncompetitive in others.

While the new process is adaptable to almost any steel casting design, there are certain designs which do not lend themselves ideally to the production concept. These include components requiring relatively large print areas, fine or complex core placements, and deeply recessed mold pockets. Although it is possible to overcome these limitations in the process, the high labor cost involved because of extraordinary attention or supervision makes such production impractical in all but isolated cases.

In cost considerations, the ceramic mold process also has limitations. Since it invades the field of precision casting, a deciding factor in selection or rejection of the new process is the number of pieces to be cast from one design. When this quantity is approximately 500 or less, the short lead time and low pattern cost of ceramic molding give it definite cost advantages. As quantity requirements exceed 500 or more, the high first cost of competing precision casting processes is more easily justifiable. For large quantities of small intricate parts, the lost wax process would probably be selected. For components up to about 2 lb in weight, either lost wax or ceramic mold casting might be selected. In large sizes, however, the new process without expendable patterns has the advantage.

COMPARISON WITH OTHER CASTINGS

Casting Requirements	Ceramicast Castings	Precision Castings	Green Sand Castings	Shell Mold Castings
SURFACE SMOOTHNESS	80-125 micro-in.	40-125 micro-in.	200-500 micro-in.	80-165 micro-in.
INTRICACY	Excellent, approaching but not equalling precision castings.	Excellent	Fair	Excellent but not equal to Ceramicast
THINNESS OF METAL SECTIONS	Excellent	Excellent	Fair	Good
TOLERANCES	Good to excellent	Excellent	Fair	Good
MACHINING COSTS	Machining greatly reduced, sometimes but not always eliminated	Minimum machining required	Relatively high cost	Slightly higher than Ceramicas
LEAD TIME	Very short lead time	Longest lead time	Shortest lead time	Long lead time
ADAPTABILITY TO VARIOUS SIZES	Casting size not restricted except above 100 lb for the top size of the casting	Restricted to small castings	No size limitations	Comparable to Ceramicast
ADAPTABILITY TO VARIOUS METALS AND ALLOYS	No limitations	No limitations	Almost no limitations	Almost no limitations except low carbon steels
PATTERN COSTS	Very low cost; jobbing wood or metal patterns may be used	Very high cost	Very low cost	Very high cost but less than precision castings
PROTOTYPE ADAPTABILITY	Low cost	High cost	Not applicable	Generally, not applicable

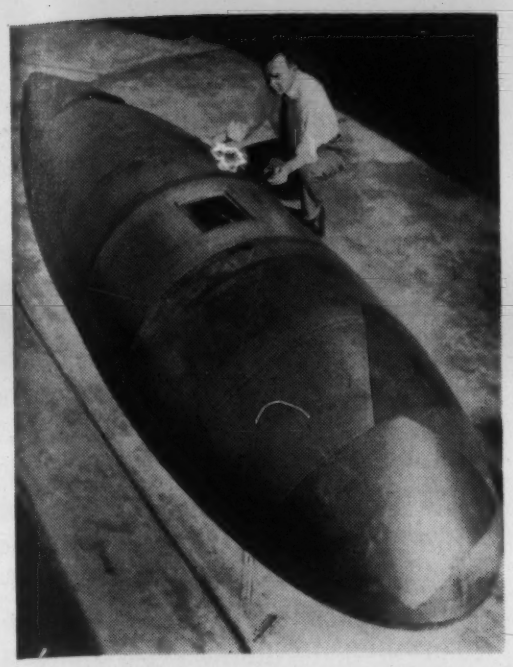
Note: This table is compiled for comparison only and is not to be considered absolute. For exact data, it is necessary to consult the foundry engineer on the particular design involved.

How the Process Works

In ceramic mold casting, a mixture of fine and coarse sillimanite, liquid hydrolyzed ethyl silicate and a liquid catalyst are mixed and poured immediately over a pattern. The mix sets in a few minutes to form a jel. During this stage the mold is flexible which facilitates stripping from the pattern. Following stripping, the mold is ignited with a torch to burn off the alcohol, assembled and fired at red heat in a furnace. The result is a rigid mold ready for use.

During burning of the alcohol, crazing occurs on the mold face, and the surface is covered with a network of hairline cracks. However, these cracks are too fine to permit metal penetration, and the casting surface is not impaired. As a matter of fact, the crazed surface has the advantage that it is very permeable and, therefore, no artificial venting is required. Further, the mold is immune to thermal shock since the fine cracks permit thermal expansion to occur.

Pouring can be done while the mold is hot or after it has been cooled, the choice being based on the requirements of the specific part being produced.



Aluminum+plastics in flyaway pod

A formable aluminum honeycomb sandwich core material saves about 65% in lay-up time during forming of this outsized flyaway pod. Twenty feet long up to five feet in diameter, the pod is fabricated in sections using Multiwave aluminum foil core which nests easily in the compound contoured sections without preliminary shaping. Glass-reinforced phenolic resin is layed up over the core. Manufactured by Narmco Metlbond Co. for Convair, the pods utilize sandwich construction to reduce weight and obtain contoured sections with a minimum of production and tooling costs.

MATERIALS AT WORK

The forging industry *is showing increased interest in leaded steels for applications in which the part is to be finished in the as-forged condition.*
(Chrysler Corp.)

Leaded Forging Steels

Leaded steels have an advantage when ease of machining is the deciding factor in selecting a forging steel.

by Kenneth Rose, *Midwestern Editor, Materials & Methods*

■ Depending on the application, a wide range of steel compositions is available for the production of forgings. For example, the engineer might select AISI 1020 carbon steel for the economical production of parts requiring moderate strength. Or he might choose an alloy steel such as AISI 4140 for parts which require heat treatment to develop the properties required. On the other hand, if extensive machining or high quality machined surfaces are a requirement, ease of machining can be the deciding factor in steel selection.

There are a number of ways of improving the machinability of steel. Spherodizing heat treatments can be employed or elements such as sulfur, selenium and lead can be added. If a steel is to be forged, however, resulfurized steels are not generally suitable since an addition of sulfur sufficient to effect substantial improvement in machinability causes the steel to be hot short in forging. For applications in which the part is to be used in the as-forged condition and even for those where heat treatment is required, the forging industry is showing increased interest in leaded steels.

Typical leaded steels now being used for the production of forged parts are given in a table. These steels are standard AISI compositions to which 0.15 to 0.35% lead has been added. The lead is insoluble in the steel and is held in the form of very fine particles distributed uniformly through the matrix. These particles act as chip-breakers and improve the machinability considerably. For example standard 4140 steel has a machinability rating of perhaps 60% of that of B1112 while the leaded version is rated at about 80%. This improvement in machinability is achieved with no loss in properties. It is generally agreed by both producers and consumers that mechanical properties and workability are not impaired by the addition of lead.

Forging operations with the leaded steels can be carried out in the same way as for corresponding compositions in nonleaded types. There is no tendency for the lead to migrate, even at forging temperatures, for it is "locked" in the crystalline matrix of the steel. Lead is lost from the surface in minute amounts, but because there is no migration of the lead from the interior of the forging billet, there is no formation of a deleaded zone corresponding with usual loss of carbon from

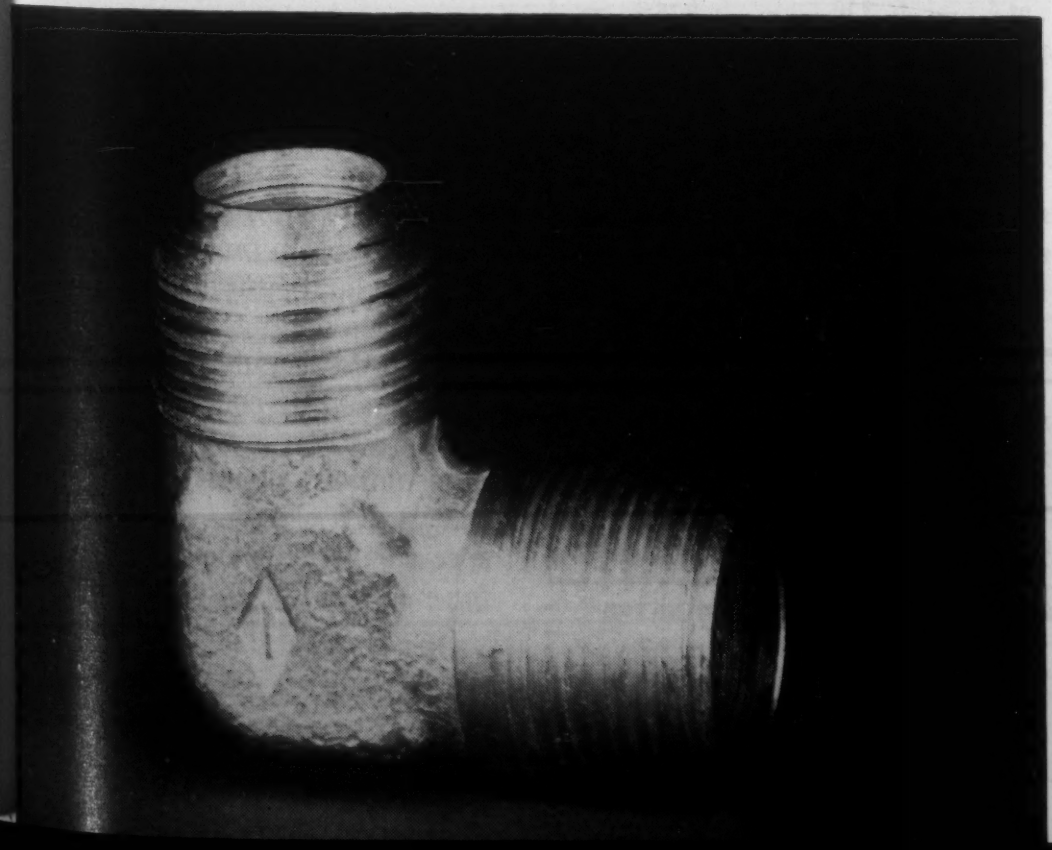
the surface of steel heated in a decarburizing atmosphere. The lead lost becomes a part of the oxide on the forging billet; some of it may be volatilized under certain conditions of temperature and atmosphere.

Since the major effect of the lead addition is improvement in machinability, selection of the steel can be made on the same basis as that used for the regular grades. Thus, 1018 and 1025 leaded can be used for the production of general forging products and can be carburized or welded as readily as the standard varieties. If somewhat greater strength is required in small or medium size forgings, 1045-leaded could be selected. For parts requiring heat treatment to develop the necessary properties, 4140-leaded or 8620-leaded can be selected.

LEADED FORGING STEELS—CHEMICAL COMPOSITION, %

Type	Carbon	Manganese	Phosphorus (Max)	Sulfur (Max)	Silicon	Lead	Other
1018	0.15/0.20	0.60/0.90	0.040	0.050	—	0.15/0.35	—
1025	0.22/0.28	0.30/0.60	0.040	0.050	—	0.15/0.35	—
1045	0.43/0.50	0.60/0.90	0.040	0.050	0.15/0.30	0.15/0.35	
4140	0.38/0.43	0.75/1.00	0.040	0.040	0.20/0.35	0.15/0.35	Chromium 0.80/1.10 Molybdenum 0.15/0.25
8620	0.18/0.23	0.70/0.90	0.040	0.040	0.20/0.35	0.15/0.35	Nickel 0.40/0.70 Chromium 0.40/0.60 Molybdenum 0.15/0.25

Pipe elbow *(below) for high pressure service forged from leaded steel to insure good machinability and clean threads.* ***(Imperial Brass Manufacturing Co.)***



Applications

A wing nut for a pipe flaring tool is required to withstand rather high loads and may undergo considerable abuse in service. Forged steel was decided upon for this piece. In order to perform the internal threading rapidly and cleanly, it was decided to use a leaded low carbon steel for the job. High production was a requirement, and the pieces were hammer forged between multiple dies by Cornel Forge Co. A three-stage die with six impressions was used to produce six forged nuts at a time. Starting with rod stock, a roll operation formed six knobs on the length of rod in the die. In the next stage, the rougher, the general shape of the wing nut was given to each knob. In the finisher, the six wing nuts were given final forged form.

A midwest manufacturer of automotive equipment and tools has recently started to use 8620-leaded to produce various parts. Marked improvement in machinability is achieved.

The decision to use a leaded steel may sometimes be made where the amount of machining after forging is relatively small. A pipe elbow, made by Imperial Brass Mfg. Co., and intended for high pressure work, is produced as a forging to obtain the high strength and uniform quality required by the severe service conditions. The solid forging is then bored out, and the two ends are threaded. The nature of the service requires that the threads be cleanly cut. In order to obtain the quality of machining required, the elbow is made of a leaded steel alternate of SAE 1015.

Acknowledgement

The writer wishes to acknowledge the assistance of the Inland Steel Co. in the preparation of this article.

How The Lead Is Added

Inland Steel Co., has patented a process for adding lead to steel. The method is to shoot a stream of finely divided lead at the stream of molten steel running from the ladle to the ingot mold. With proper control, the particles of lead are distributed evenly in the steel. Any steel can be leaded with the exception of rimmed steels of very low carbon content.

The lead content in the steel is 0.15 to 0.35% and this amount improves machinability to values corresponding roughly to those which would be obtained by using 0.08 to 0.13% sulfur instead of the lead.

Take a look at the ratios shown black in the table below. They show that NOL 24, already proved superior to other glass finishes in epoxy and phenolic laminates, is also equal to a standard commercial finish used in polyester laminates. It may be truly . . .

A Universal Glass Finish for Reinforced Plastics

	Group 1 Laminates				Group 2 Laminates			
	NOL 24		NOL 24/Volan A		NOL 24		NOL 24/Volan A	
	Avg	Min	Avg	Min	Avg	Min	Avg	Min
TENSILE STRENGTH (in warp direction):								
Dry, 10^3 psi	53.3	50.4	**1.02**	0.98	53.7	50.1	**1.11**	1.05
Wet, 10^3 psi	52.2	51.0	**1.04**	1.05	51.6	49.6	**1.11**	1.08
Wet retention	0.98	1.01	1.02	1.06	0.96	0.99	1.00	1.03
TENSILE MODULUS (in warp direction):								
Dry, 10^6 psi	2.43	—	**0.95**	—	2.73	—	**0.92**	—
Wet, 10^6 psi	2.18	—	**0.84**	—	2.93	—	**0.97**	—
Wet retention	0.90	—	0.88	—	1.07	—	1.05	—
COMPRESSIVE STRENGTH:								
Dry, 10^3 psi	40.6	38.1	**0.93**	1.06	43.0	40.7	**0.98**	1.06
Wet, 10^3 psi	40.1	37.4	**1.00**	0.94	37.0	36.7	**0.98**	1.06
Wet retention	0.99	0.98	1.07	0.88	0.86	0.90	1.00	1.00
COMPRESSIVE MODULUS:								
Dry, 10^6 psi	3.60	—	**0.98**	—	3.82	—	**0.88**	—
Wet, 10^6 psi	3.52	—	**0.98**	—	3.85	—	**1.03**	—
Wet retention	1.98	—	1.00	—	1.00	—	1.18	—
FLEXURAL STRENGTH:								
Dry, 10^3 psi	65.7	62.3	**1.10**	1.08	57.8	55.8	**0.91**	0.92
Wet, 10^3 psi	59.5	58.4	**1.10**	1.12	53.5	53.1	**0.96**	0.99
Wet retention	0.91	0.94	1.00	1.04	0.93	0.95	1.05	1.07
FLEXURAL MODULUS:								
Dry, 10^6 psi	3.54	—	**1.03**	—	3.10	—	**0.75**	—
Wet, 10^6 psi	3.57	—	**1.07**	—	3.08	—	**0.84**	—
Wet retention	1.00	—	1.03	—	1.00	—	1.12	—
TENSILE STRENGTH (at 45 deg to warp):								
Dry, 10^3 psi	21.9	21.7	**1.06**	1.10	22.5	20.1	**1.09**	0.99
Wet, 10^3 psi	22.5	20.3	**1.18**	1.08	17.8	16.4	**1.00**	0.96
Wet retention	1.02	0.94	1.10	0.98	0.79	0.81	0.92	0.98
INTERLAMINAR SHEAR STRENGTH:								
Dry 10^3 psi	1.50	1.35	**1.02**	0.97	1.49	1.46	**1.03**	1.03
Wet, 10^3 psi	1.49	1.41	**1.03**	0.98	1.54	1.47	**1.05**	1.01
Wet retention	1.00	1.04	1.00	1.01	1.03	1.00	1.03	0.98
WATER ABSORPTION, %	0.16	—	0.9	—	0.19	—	1.2	—

COMPARISON OF MECHANICAL PROPERTIES OF POLYESTER LAMINATES

by Eric L. Strauss,
Structural Plastics Engineer, The Glenn L. Martin Co.

■ A recent evaluation by this company indicates that polyester-glass laminates made of fabric treated with NOL 24 finish are equal to or slightly better than comparable Volan A laminates for nearly all loading conditions evaluated. In most cases, average wet strength retention of NOL 24 laminates exceeded 85%. Since the superiority of NOL 24 for epoxy and phenolic laminates has previously been established, NOL 24 appears to be more versatile than any other glass finish now in commercial use.

The comparison with Volan A, selected as a typical commercial finish, is based on the results obtained from three sets of test panels. Each set consisted of one NOL 24 panel and one Volan A panel, the two panels having been fabricated concurrently. All panels were made with 181 glass cloth and Laminac 4128 polyester resin. Composition, thickness and some physical data are shown in the smaller of the two accompanying tables.

Mechanical properties were determined both for dry laminates and for laminates after 2-hr immersion in boiling water. Tension, compression and flexure specimens generally conformed to Federal Specification L-P-406; the interlaminar shear specimen is shown in a sketch. At least three specimens per panel were tested for each loading condition investi-

DESCRIPTION OF TEST PANELS

Group	Finish	Number of plies	Thickness, in.	Resin content, % by wt	Specific gravity	Barcol hardness
1	Volan A	15	0.144	36.0	1.80	65
	NOL 24	15	0.139	36.6	1.80	66
2	Volan A	12	0.105	31.8	1.90	68
	NOL 24	12	0.111	33.8	1.88	68
3	Volan A	15	0.154	40.1	1.75	67
	NOL 24	15	0.140	34 6	1.83	66

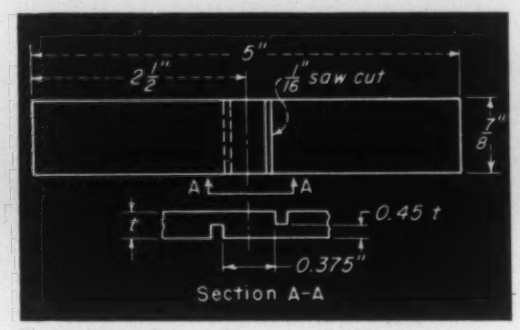
gated. Results of tests on two groups of panels are shown in the first table. (Only water absorption and flexural properties were determined for the third set of panels. Results for water absorption and flexural stiffness were within the ranges shown by tests on the other panels. The NOL 24 panel showed somewhat lower wet retention of flexural strength than in the other two sets—slightly less than 85%.) The data show:

1. Although properties of corresponding panels differ slightly, neither finish appears to be markedly superior to the other. With both finishes, wet strength and stiffness approach and in some cases exceed the dry properties. Similarity in dry properties and in wet retention of properties is shown by the ratios in the table of mechanical properties. Most ratios are within 5 to 10% of 1.0.

2. Compared with Volan A, NOL 24 appears to increase dry tensile strength in the warp direction by about 5%, and to decrease the corresponding modulus of elasticity by about 5%. Average wet retention of tensile strength exceeded 95% for all panels tested.

3. The two finishes do not differ significantly in their effect upon compressive strength and stiffness. Average wet retention of compressive strength appears to be satisfactory with both finishes.

4. Comparison of average and minimum dry strengths indicates that NOL 24 laminates have flexural strengths about 5% higher than those of Volan A laminates. Although wet strength retention of one panel in each case fell slightly below 85%, the other panels retained more than 90% of their dry strength. The two finishes apparently do not differ in their effect upon flexural modulus of elasticity.



Interlaminar shear specimen.

5. Lowest average wet strength retention, 79%, was obtained for a NOL 24 panel tested in tension at 45 deg to the warp direction. However, comparison of wet strengths indicates that a 5% increase in retained 45-deg tensile strength can be attributed to the NOL 24 finish.

6. The two finishes do not differ significantly in their effect upon interlaminar shear strength. Average wet strength retention exceeded 95% for all panels tested. (Figures given in the table do not represent true interlaminar shear strengths of these reinforced plastics, since excessive bending in the lap joints caused failures.)

7. The two finishes do not differ significantly in their effect upon water absorption. Average water absorption after 2-hr immersion in boiling water was less than 0.2% for all panels tested.

Finishes for Glass Fibers

The strength of glass-reinforced plastics laminates, either dry or after exposure to high humidity, depends partly on how strongly the glass fibers and the resin adhere to each other. Because the main causes of inferior mechanical bonds are insufficient wetting of the glass fibers by the resin and by the moisture on the glass surface, a suitable coupling agent is needed to provide a chemical linkage between the resin and the glass reinforcement.

In recent years improved finishes (such as Garan, Owens Corning and Volan A) have replaced the older 114 finish for aircraft structural components. Although these finishes were specifically designed for use with polyester resins, their use has been extended to epoxy and phenolic resin laminates. Whereas wet strength retention of polyester laminates made with the old 114 finish was only about 60%, laminates made with the improved finishes have wet strength retention of 80%.

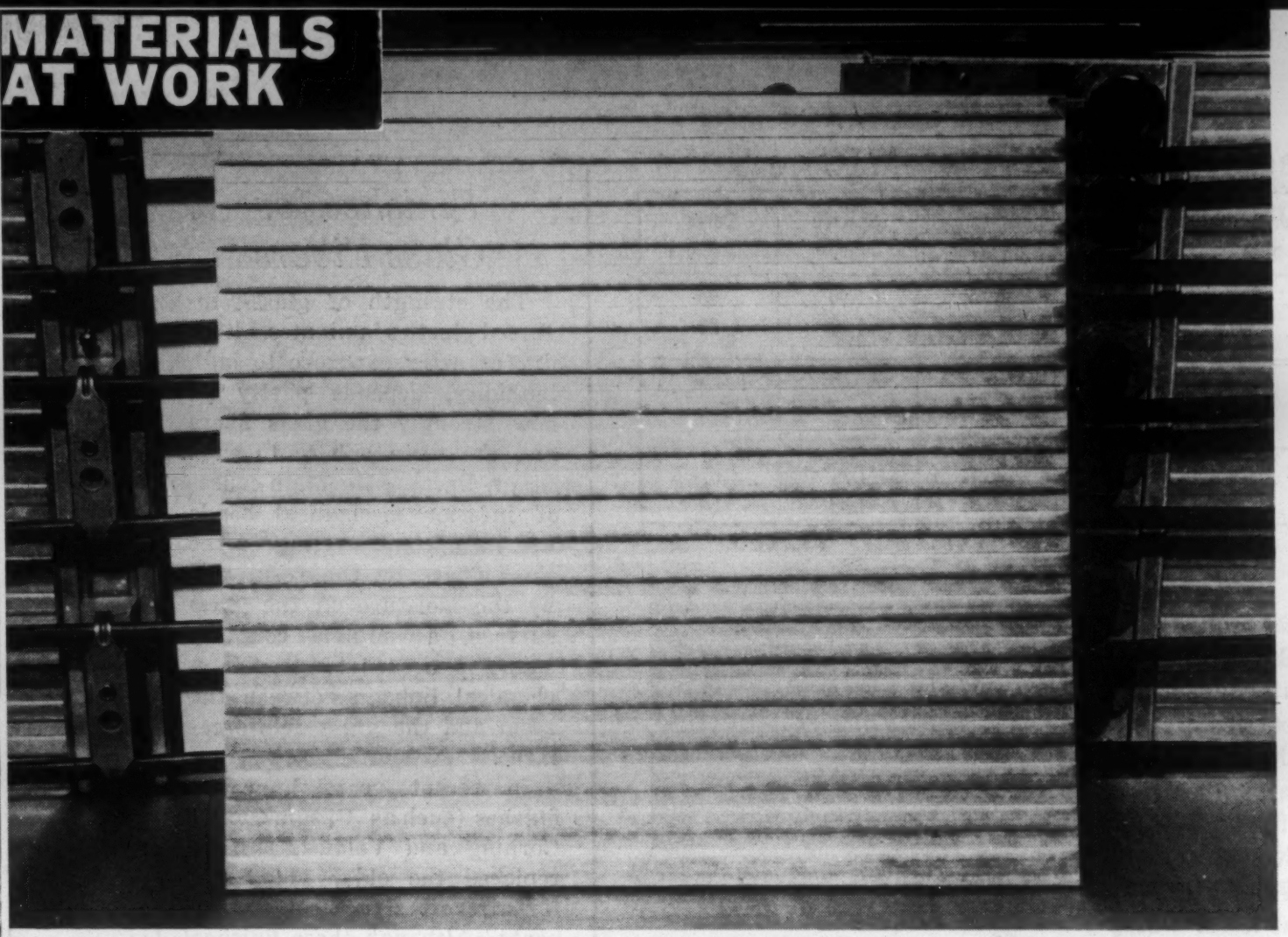
Still more recently the Naval Ordnance Laboratory has developed a series of halosilane finishes specially designed to react with epoxy, phenolic and polyester resins. One of these, NOL 24 (product of the reaction between equimolar amounts of allyltrichlorosilane and resorcinol), can now be used to treat glass fabrics on a commercial basis. Previously published data show that epoxy and phenolic laminates utilizing NOL 24 finish have flexural strengths, dry and wet, about 15 to 20% higher than comparable laminates made with Volan A. Until now, however, there have been no data available on the effect of NOL 24 on polyester-glass laminates.

References

Clark, G. A., "Evaluation of Finishes for Glass Fibers", Modern Plastics, Vol. 30, No. 3, 142-44, Nov., 1952.

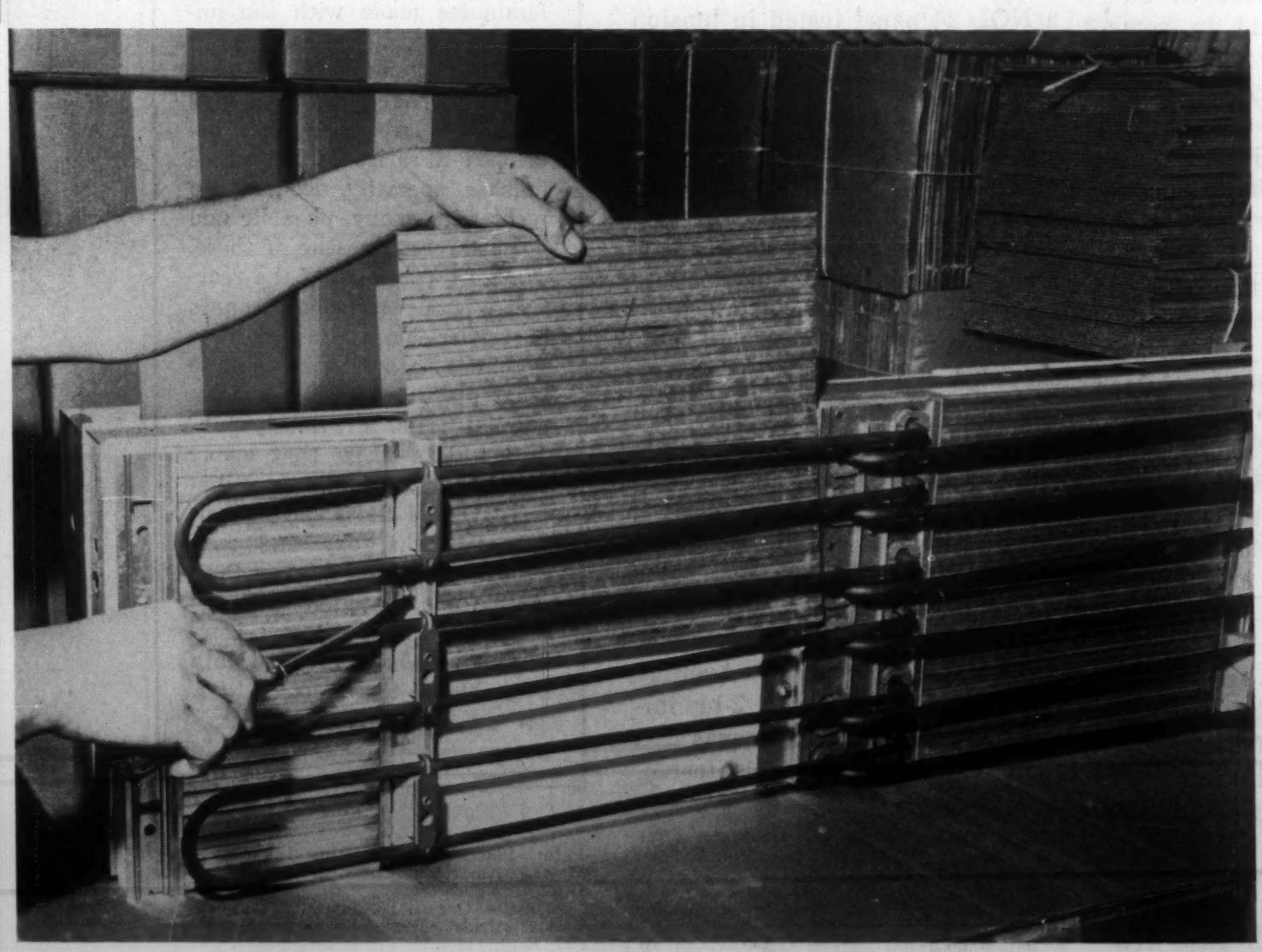
Erickson, P. W., Silver, I., and Perry, Jr., H. A., "Universal Type Chemical Finishes for Glass Fibers Used in Reinforced Plastics", a paper delivered before the Division of Paint, Plastics and Printing Ink Chemistry of the American Chemical Society, Mar., 1954.

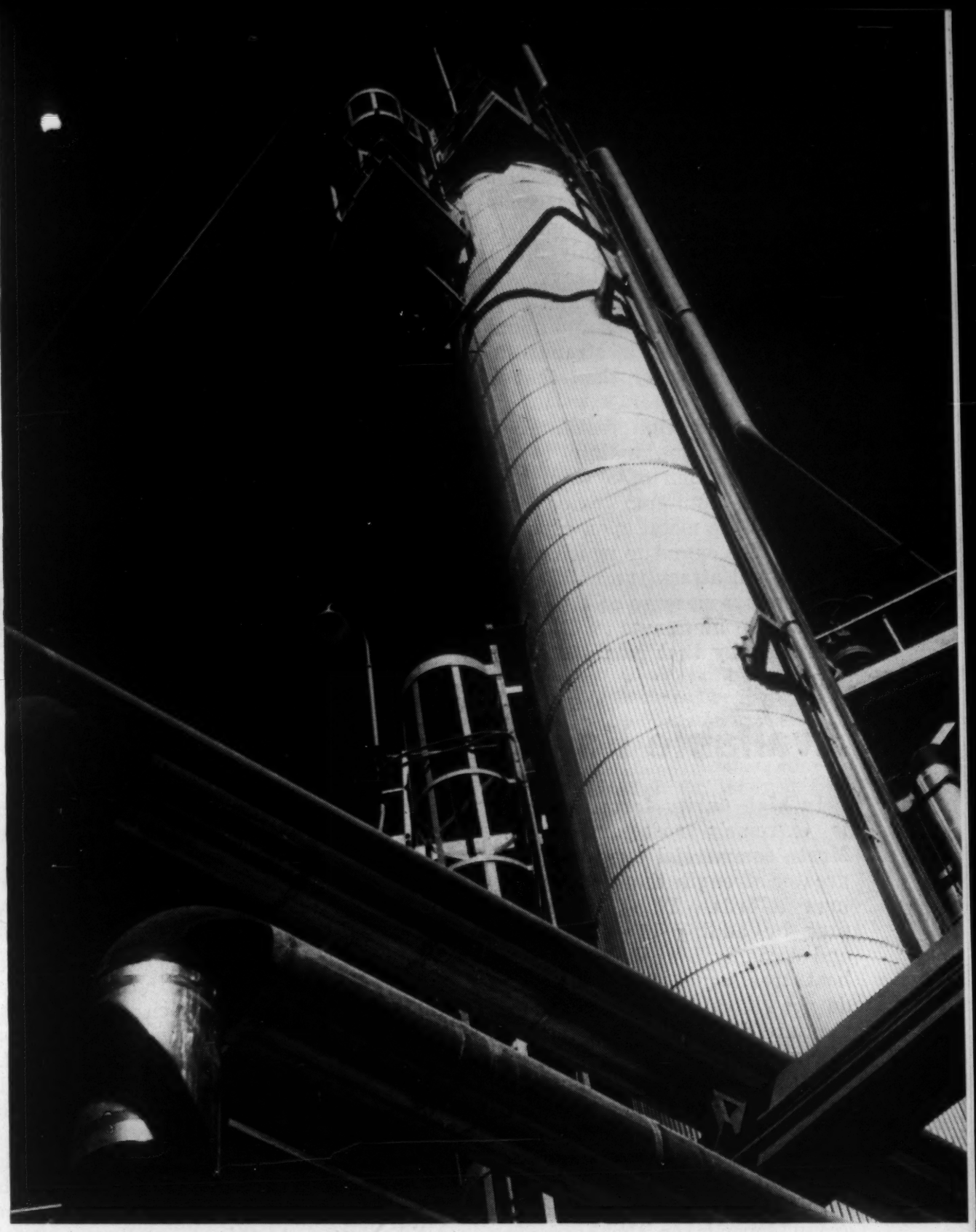
"Plastics Organic: General Specifications, Test Methods", Federal Specification L-P-406, Sept., 1952.



Embossed aluminized steel

Fluted patterns in these aluminized steel sheets are said to provide high rigidity at elevated temperatures and to reflect maximum energy. They are used in Chromalox Radiant Panels which deliver over 9200 Btu per sq ft per hr. Panels form complete oven sections with built-in insulation. Aluminized steel panels can be easily removed for cleaning. Chromalox far-infrared radiant panels are manufactured by Edwin L. Wiegan Co. of Pittsburgh, with sheets of Rigid-tex aluminized steel produced by Rigidized Metals Corp. of Buffalo.





by M. W. Riley,
Associate Editor,
Materials & Methods

Wrought Aluminum Alloys

Here is an up-to-date guide to the selection and use of wrought aluminum alloys. Comprehensive tables are designed to pinpoint specific information you need to select the proper alloy for your specific job. This manual tells you about:

- *Available Forms and Conditions*
- *Engineering Properties*
- *Forming and Joining Aluminum*
- *Finishes for Aluminum*

MATERIALS & METHODS MANUAL No. 123

This is another in a series of comprehensive articles providing useful data on characteristics and uses of materials, parts and finishes.

JANUARY 1956

■ The stature which aluminum has achieved in the materials field is attributable to its unique combination of physical and mechanical properties. Aluminum, with a specific gravity of only 2.7, is approximately ⅔ as heavy, volume for volume, as iron and ⅓ as heavy as copper. Certain aluminum alloys have a strength-to-weight ratio better than that of high strength steels.

Aluminum's high resistance to corrosion is due mainly to the protective action of a thin, hard layer of aluminum oxide that forms on the metal upon exposure to air. The extent to which a substance will attack the oxide layer is largely a measure of the extent to which aluminum will resist corrosion by that medium. Some of the high-strength alloys are subject also to intergranular corrosion and stress corrosion in saline or acid atmospheres and liquids unless the alloy is clad with corrosion-resistant alloys or is otherwise protected.

On an equal volume basis, commercially pure aluminum has 62% of the electrical conductivity of standard copper. On an equal weight basis, however, the conductivity of aluminum is approximately 213% that of standard copper. Alloying the metal, which increases its strength, also reduces its electrical conductivity. So where mechanical strength and conductance requirements are both high, a compromise must be made in using an alloy with higher strength but lower conductivity than commercially pure aluminum.

Aluminum is a versatile material in that a wide variety of mechanical characteristics is obtainable by the proper choice of alloy, heat treatment and cold work. In specifying the temper for any given product, the fabricating process and the amount of cold work involved should be kept in mind so that the metal in its finished shape will have the desired characteristics.

Other advantages in the material are its ease of workability, excellent machinability, high thermal conductivity, high reflectivity, non-toxicity, non-sparking and non-magnetic characteristics, and the wide variety of finishing possibilities.

Available Forms and Conditions

In high purity form aluminum is extremely soft and ductile. Most commercial uses require greater strength than pure aluminum affords. This is achieved first by adding other elements, and secondly by cold working or heat treatment. Since all alloys do not respond to heat treatment they are divided roughly into two categories, non-heat-treatable and heat-treatable. An accompanying box explains the alloy and temper designation systems.

Non-heat-treatable alloys

Initial strength of alloys in this group depends on the hardening effect of elements such as manganese, silicon, iron and magnesium, singly or in various combinations. Non-heat-treatable alloys are usually in the 1000, 3000, 4000, or 5000 series. These alloys are work-hardenable and further strengthening can be achieved by varying degrees of cold working, denoted by the —H series of tempers. Alloys containing appreciable amounts of magnesium when supplied in strain hardened tempers are usually given a final elevated temperature treatment called *stabilizing* to insure stability of properties.

Heat-treatable alloys

Initial strength of alloys in this group is improved by addition of alloying elements such as copper, magnesium, zinc and silicon. The heat-treatable alloys generally fall in the 2000, 6000, or 7000 series. Because these elements singly or in various combinations show increasing solid solubility in aluminum with increasing temperature, it is possible to subject them to thermal treatments which produce pronounced improvements in strength.

The initial solution heat treatment puts the soluble element in solid solution. This is followed by rapid quenching, usually in water, which momentarily retains soluble constituents in a super-saturated solid solution. At this stage alloys are most easily worked. At room or elevated temperatures the alloys are not stable after quenching and precipitation of the constituents from the super-saturated solution begins. After aging for a period of several days at room temperature, alloys gain considerably in strength, due to precipitation to the grain boundaries. Many alloys approach a stable condition at room temperature in a few days, but some, particularly those containing magnesium and silicon or magnesium for zinc, continue to age harden for long periods of time at room temperature. Even further strengthening and stabilization of properties can be achieved by artificial aging or precipitation hardening consisting of heating for a controlled time at temperatures which are slightly elevated.

Plate, sheet and foil

A solid section of aluminum rolled to a thickness of 0.250 in. or heavier is called *plate*. Thicknesses from 0.006 to 0.249 in. are classified as *sheet*. And thicknesses under 0.0059 in. are termed *foil*.

Heat-treatable alloys are available only with regular mill finish. In the non-heat-treatable alloys, coiled and flat sheet can be furnished with a variety of finishes. Where no special processes are used, sheet carries a mill finish, which is uncontrolled and may vary from sheet to sheet, depending on fabricating conditions. The term *one-side-bright-mill-finish* refers to sheet having a moderate degree of brightness on one side, while the finish on the reverse side is uncontrolled and may have a dull, non-uniform appearance. Materials having a *standard-one-side-bright finish* have a uniformly bright, lustrous surface on one side and an uncontrolled finish on the reverse. *Standard bright finish* refers to sheet materials having a relatively bright, uniform appearance on both sides, but somewhat less lustrous than standard-one-side-bright material. The term *dull finish* refers to an uncontrolled dull mill finish while *gray plate finish* is a controlled

Alloy and Temper Designation Systems

Wrought aluminum and wrought aluminum alloys are designated by a four digit numbering system. The first digit of the designation serves to indicate alloy groups. The last two digits identify the aluminum alloy or indicate the aluminum purity. The second digit indicates modifications of the original alloy or impurity limits.

Aluminum

In the 1xxx group for minimum aluminum purities of 99.00% and greater, the last two of the four digits in the designation indicate the minimum aluminum percentage in hundredths. In the second digit, zero indicates that there is no special control on individual impurities, while integers 1 thru 9 indicate special control of one or more individual impurities.

Aluminum alloys

In the 2xxx thru 8xxx alloy groups, the last two of the four digits serve only to identify different alloys in the group. When new alloys become commercially developed, these last two digits are assigned consecutively beginning with xx01. In the second digit, zero indicates the original alloy, while integers 1 thru 9 indicate alloy modifications.

Alloy Group Designations

Aluminum—99.00% min and greater		1xxx
Aluminum alloys grouped by major alloying elements	Copper	2xxx
	Manganese	2xxx
	Silicon	4xxx
	Magesium	5xxx
	Magnesium and Silicon	6xxx
	Zinc	7xxx
	Other	8xxx
Unused Series		9xxx

Temper designation system

Standard temper designation system consists of a letter indicating the basic temper, separated from the alloy designation by a dash. Except for the annealed and as-fabricated condition, temper is more specifically defined by the addition of one or more digits. Symbols used, conditions they describe, and explanation for each follow:

–F: As Fabricated—Condition resulting from normal manufacturing operations. No guarantee of mechanical properties.

–O: Annealed, recrystallized—Softest temper of wrought alloy products.

–H: Strain Hardened—Applies to products which have their strength increased by strain hardening with or without supplementary thermal treatment to produce partial softening. The —H is always followed by two or more digits. The first digit indicates the specific combination of basic operations and the following digit or digits, the final degree of strain hardening, as explained below.

–H1: Strain Hardened Only—Second digit designates amount of cold work performed. The digit 8 represents hardest commercially practical temper, written thus: —H18. Half hard material is designated —H14, quarter hard —H12, and so on. A third digit is often used to identify a special set of properties. For example, —H141 may represent material with the same minimum properties as —H14, but with maximum values that are closer than standard. Extra hard tempers are designated by the second digit 9.

–H2: Applies to materials worked to a harder temper, then reduced to desired strength level by partial annealing. Residual cold work is then designated by the same method employed for the —H1 series.

–H3: Strain Hardened and Partially Annealed—Applies to magnesium-containing alloys in strain hardened condition, stabilized by low temperature heating, thus lowering slightly their strength and increasing ductility. Degree of strain hardening is indicated in the usual way by one or two following digits.

–W: Unstable Condition Following Solution Heat Treatment—This designation, because of natural aging, is specific only when the period of aging is indicated, e.g., 2024—W (½hr); 7075—W (2 mo).

–T: Treated to Produce Stable Tempers other than —F, —O, or —H—Applies to products thermally treated to produce stable tempers with or without supplementary strain hardening. The —T followed by the numerals 2 to 19, inclusive, designates one specific combination of basic operations. Should some other variation of the same basic operations be applied to the same alloy, resulting in different characteristics, other digits are added to the basic designation. A period of natural aging at room temperature may occur between or after the operations listed; however, it is not indicated by designation.

–T2: Annealed (castings only)

–T3: Solution Heat Treated and Cold Worked, Naturally Aged to Substantially Stable Temper —Applies where cold work is performed to improve strength. Also applies to those products in which the effect of cold work is recognized in applicable specifications (2024 flat sheet, heat treated by supplier, is designated 2024—T3). No control is exercised over cold work during the natural aging cycle.

–T4: Solution Heat Treated and Naturally Aged to a Substantially Stable Condition—Applies when products are not cold worked after heat treatment, and also when applicable specifications do not recognize the effect of cold work (6061 flat sheet heat treated by the supplier is designated 6061—T4). Alloy 7075 does not have a commercial —T4 designation.

–T5: Artifically Aged Only—Applies to products artifically aged without prior solution heat treatment.

–T6: Solution Heat Treated and Artifically Aged — Applies to products not cold worked after solution heat treatment or in which the effect of flattening or straightening is not recognized in applicable specifications. (Whether flattened or not, 6061 heat treated and aged is designated 6061—T6, and 7075 treated in the same manner is 7075—T6.)

–T7: Solution Heat Treated and Stabilized—Applies to products where stabilizing temperature and time carry alloy beyond the point of maximum hardness, for control of growth and/or residual stress.

–T8: Solution Heat Treated, Cold Worked and Artifically Aged—Applies when the cold working is done to improve strength, and also when the cold working effect of flattening or straightening is recognized in applicable specifications.

–T9: Solution Heat Treated, Artifically Aged and Cold Worked—6061 wire heat treated, artifically aged and cold worked is 6061-T91.

–T10: Artifically Aged and Cold Worked — Applies today only to castings.

Source: Aluminum Association

dull gray matte-like mill finish.

Several alloys are available in alclad form, that is, clad with high purity aluminum or an aluminum alloy that is anodic to a relatively high strength core alloy. This thin cladding material, rolled on one or both sides of the sheets, provides a high degree of corrosion resistance to those alloys with relatively poor inherent corrosion resistance, or to those alloys susceptible to intergranular corrosion.

WROUGHT ALLOYS AND PRODUCTS

(X indicates products in which alloy is normally produced)

Alloy	Sheet	Plate	Tube		Pipe	Shapes		Rod	Bar	Wire	Rivets	Forgings & Forging Stock
			Drawn	Extruded		Rolled	Extruded					
EC	X	X	X	X	X	X	X	X	X	X	—	—
1100	X	X	X	X	X	—	X	X	X	X	X	X
2011	—	—	—	X	—	—	X	X	X	X	—	—
2014	—	X	X	X	X	X	X	X	X	—	—	X
Alclad 2014	X	X	—	—	—	—	—	—	—	—	—	—
2017	—	—	—	—	—	—	—	X	X	X	—	—
2018	—	—	—	—	—	—	—	—	—	—	—	X
2024	X	X	X	X	X	—	X	X	X	X	X	—
Alclad 2024	X	X	—	—	—	—	—	—	—	—	—	—
2025	—	—	—	—	—	—	—	—	—	—	—	X
2117	—	—	—	—	—	—	—	—	—	X	X	—
2218	—	—	—	—	—	—	—	—	—	—	—	X
3003	X	X	X	X	X	—	X	X	X	X	—	X
Alclad 3003	X	X	X	—	X	—	—	—	—	—	—	—
3004	X	X	—	—	—	—	—	—	—	—	—	—
Alclad 3004	X	X	—	—	—	—	—	—	—	—	—	—
4032	—	—	—	—	—	—	—	—	—	—	—	X
4043	—	—	—	X	—	—	X	—	—	X	—	—
5005	X	X	—	—	—	—	—	—	—	—	—	—
5050	X	X	X	—	—	—	—	X	X	X	—	—
Alclad 5050	X	X	—	—	—	—	—	—	—	—	—	—
5052	X	X	X	—	X	—	—	X	X	X	—	—
5056	X	X	—	—	—	—	—	X	—	X	X	—
Alclad 5056	—	—	—	—	—	—	—	—	—	X	—	—
5086	X	X	—	—	—	—	—	—	—	—	—	—
5154	X	X	—	—	—	—	—	X	X	X	—	—
5357	X	X	—	—	—	—	—	—	—	—	—	—
6053	—	—	—	—	—	—	—	—	—	X	X	—
6061	X	X	X	X	X	X	X	X	X	X	X	X
Alclad 6061	X	X	—	—	—	—	—	—	—	—	—	—
6062	—	—	X	X	X	—	X	—	—	—	—	—
6063	—	—	X	X	X	—	X	—	—	—	—	—
6066	—	—	X	X	X	—	X	X	X	—	—	X
6151	—	—	—	—	—	—	—	—	—	—	—	X
6951	X	—	X	X	X	—	X	X	X	X	—	—
7001	—	—	—	X	—	—	X	X	X	—	—	X
7072	—	—	—	—	—	—	—	—	—	X	—	—
7075	X	X	X	X	X	—	X	X	X	X	—	X
Alclad 7075	X	X	—	—	—	—	—	—	—	—	—	—
7076	—	—	—	—	—	—	—	—	—	—	—	X
7277	—	—	—	—	—	—	—	—	—	—	X	—

Source: Aluminum Association

Foil is available in a variety of alloys, though most of it is produced in high purity aluminum. Its primary use has been in packaging, though other uses such as covering for bulk thermal insulation, sandwich structures (honeycomb), printed circuits, and other electrical uses are becoming more prevalent.

Rod bar and wire

Rod is defined as a solid round section with a diameter of 0.375 in. or greater, while *bar* is any section other than round whose greatest transverse dimension is 0.375 in. or more. Rod and bar stock is divided into the forging and nonforging groups. The forging group will be covered under the section on forging stock. Wire is a solid section whose greatest transverse dimension does not exceed 0.374 in.

Rod and bar are available in both the heat-treatable and the non-heat-treatable alloys. Rolled rod and bar are hot worked to specified dimensions. Cold finished rod and bar are reduced to specified dimensions by cold rolling or cold drawing, which provides closer dimensional tolerances and better finish than are obtainable from hot rolling only. Both heat-treatable and non-heat-treatable alloys are available in the annealed or as-fabricated condition or in all suitable tempers.

Standard screw machine stock is a commodity classification of rod and bar which is used in large quantities for production of screw machine parts. Since it is standard stock it costs less than rolled or cold finished products. It is supplied in alloys with good machinability and is available in many sizes down to about ⅛ in. including round and hexagonal shapes.

Several rod, bar and wire alloys have excellent ductility and are readily cold headed or roll-threaded or both.

Wire is available in several general classes or commodity classifications, including manufacturers wire, rivet wire, welding wire, hexagonal wire and electrical conductor wire. Wire can be produced to specified tempers by intermediate or final annealing followed by cold reduction, or it may be heat treated to temper.

Forging stock

Forging stock is available as forging rod (round solid sections with a diameter of 3/8 in. or more), forging bar (square, rectangular, hexagonal and octagonal cross-section with greatest distance across flats of 3/8 in. or more) or forging shapes (forging stock produced in any other shape). Most rod and bar material is furnished in either hot- or cold-finished condition, while shapes are usually furnished as-fabricated. Most aluminum forging alloys contain copper, silicon or both, and a small amount of magnesium. Manganese, nickel, chromium and zinc are used to impart specific qualities to alloys.

Extruded shapes

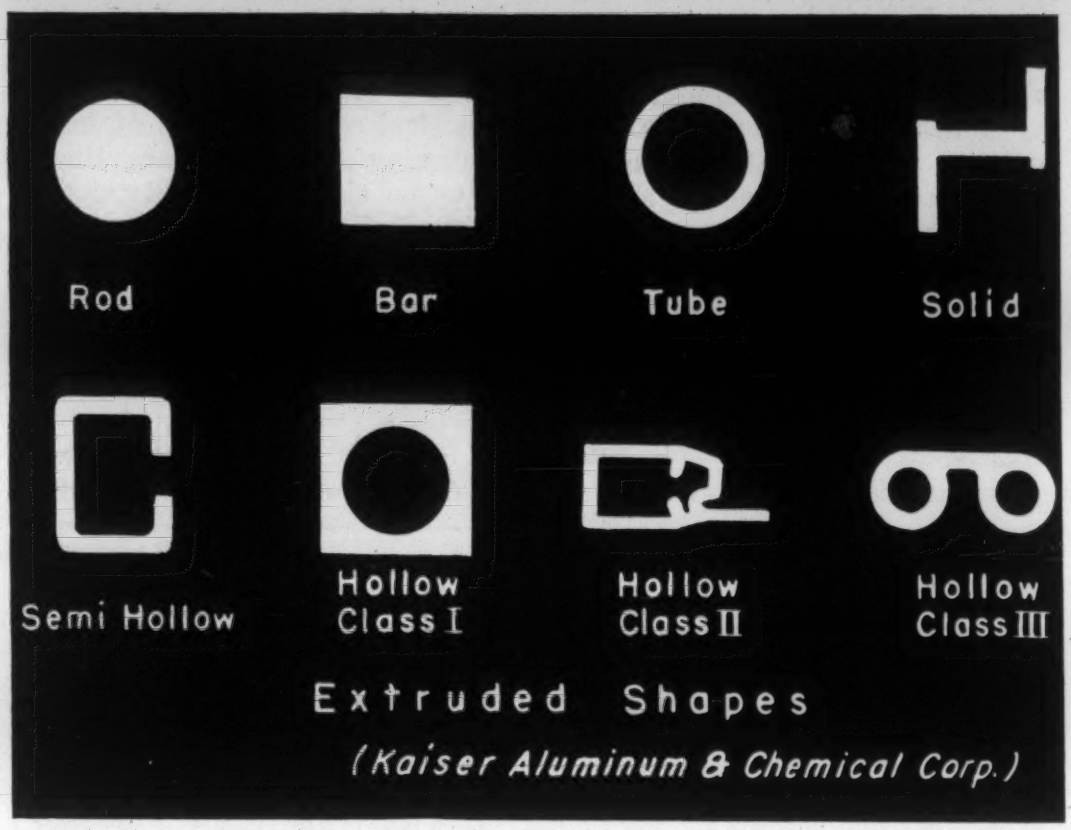
The major advantage of using extruded shapes is that theoretically any form or design in cross-section can be produced, though practical considerations of manufacturing economy place limitations on size, shape and relationship of all parts of the extrusion to each other. An accompanying

CHEMICAL COMPOSITION LIMITS[1]

AA Designation	Silicon	Iron	Copper	Manganese	Magnesium	Chromium	Nickel	Zinc	Titanium	Others		Aluminum Min[12]
										Each	Total	
EC[2]	—	—	—	—	—	—	—	—	—	—	—	99.45
1100	1.00 Si+Fe		0.20	0.05	—	—	—	0.10	—	0.05	0.15	99.00
1130[3]	0.70 Si+Fe		0.20	—	—	—	—	—	—	0.05	0.15	99.30
1160	0.40 Si+Fe		0.05	—	—	—	—	—	—	0.05	0.15	99.60
1175[4]	0.15 Si+Fe		0.10	—	—	—	—	—	—	0.02	—	99.75
1230[5]	0.70 Si+Fe		0.10	0.05	—	—	—	0.10	—	0.05	0.15	99.30
2011[6]	0.40	0.7	5.0 -6.0	—	—	—	—	0.30	—	0.05	0.15	Remainder
2014	0.50 -1.20	1.0	3.9 -5.0	0.40-1.20	0.20-0.80	0.10	—	0.25	0.15	0.05	0.15	Remainder
2017	0.80	1.0	3.5- 4.5	0.40-1.00	0.20-0.80	0.10	—	0.25	—	0.05	0.15	Remainder
2018	0.90	1.0	3.5 -4.5	0.20	0.45-0.90	0.10	1.7 -2.3	0.25	—	0.05	0.15	Remainder
2024	0.50	0.50	3.8 -4.9	0.30-0.90	1.20-1.80	0.10	—	0.25	—	0.05	0.15	Remainder
2025	0.50-1.20	1.00	3.9 -5.0	0.40-1.20	0.05	0.10	—	0.25	0.15	0.05	0.15	Remainder
2117	0.80	1.00	2.2 -3.0	0.20	0.20-0.50	0.10	—	0.25	—	0.05	0.15	Remainder
2218	0.90	1.00	3.5 -4.5	0.20	1.20-1.80	0.10	1.7 -2.3	0.25	—	0.05	0.15	Remainder
3003	0.60	0.70	0.20	1.00-1.50	—	—	—	0.10	—	0.05	0.15	Remainder
3004	0.30	0.70	0.20	1.00-1.50	0.80-1.30	—	—	0.10	—	0.05	0.15	Remainder
4032	11.0-13.5	1.00	0.50-1.3	—	0.80-1.30	0.10	0.50-1.3	0.25	—	0.05	0.15	Remainder
4043[11]	4.50-6.00	0.80	0.30	0.05	0.05	—	—	0.10	0.20	0.05	0.15	Remainder
4343[11]	6.80-8.20	0.80	0.25	0.10	—	—	—	0.20	—	0.05	0.15	Remainder
5005	0.40	0.70	0.20	0.20	0.50-1.10	0.10	—	0.25	—	0.05	0.15	Remainder
5050	0.40	0.70	0.20	0.10	1.00-1.80	0.10	—	0.25	—	0.05	0.15	Remainder
5052	0.45 Si+Fe		0.10	0.10	2.20-2.80	0.15-0.35	—	0.20	—	0.05	0.15	Remainder
5056	0.30	0.40	0.10	0.05-0.20	4.50-5.60	0.05-0.20	—	0.10	—	0.05	0.15	Remainder
5086	0.40	0.50	0.10	0.20-0.70	3.50-4.50	0.25	—	0.25	—	0.05	0.15	Remainder
5154	0.45 Si+Fe		0.10	0.10	3.10-3.90	0.15-0.35	—	0.20	0.20	0.05	0.15	Remainder
5357	0.12	0.17	0.07	0.15-0.45	0.80-1.20	—	—	—	—	0.05	0.15	Remainder
6003[7]	0.35-1.00	0.60	0.10	0.80	0.80-1.50	0.35	—	0.20	0.10	0.05	0.15	Remainder
6053	[8]	0.35	0.10	—	1.10-1.40	0.15-0.35	—	0.10	—	0.05	0.15	Remainder
6061	0.40-0.80	0.70	0.15-0.40	0.15	0.80-1.20	0.15-0.35	—	0.25	0.15	0.05	0.15	Remainder
6062	0.40-0.80	0.70	0.15-0.40	0.15	0.80-1.20	0.04-0.14	—	0.25	0.15	0.05	0.15	Remainder
6063	0.20-0.60	0.35	0.10	0.10	0.45-0.90	0.10	—	0.10	0.10	0.05	0.15	Remainder
6066	0.90-1.80	0.50	0.70-1.20	0.60-1.10	0.80-1.40	0.40	—	—	0.20	0.05	0.15	Remainder
6151	0.60-1.20	1.00	0.35	0.20	0.45-0.80	0.15-0.35	—	0.25	0.15	0.05	0.15	Remainder
6253[9]	[8]	0.50	0.10	—	1.00-1.50	0.15-0.35	—	1.60-2.40	—	0.05	0.15	Remainder
6951	0.20-0.50	0.80	0.15-0.40	0.10	0.40-0.80	—	—	0.20	—	0.05	0.15	Remainder
7001	0.35	0.40	1.6 -2.6	0.20	2.60-3.40	0.18-0.40	—	6.80-8.00	0.20	0.05	0.15	Remainder
7072[10]	0.70 Si+Fe		0.10	0.10	0.10	—	—	0.80-1.30	—	0.05	0.15	Remainder
7075	0.50	0.70	1.2 -2.0	0.30	2.10-2.90	0.18-0.40	—	5.10-6.10	0.20	0.05	0.15	Remainder
7076	0.40	0.60	0.30-1.0	0.30-0.80	1.20-2.00	—	—	7.00-8.00	0.20	0.05	0.15	Remainder
7277	0.50	0.70	0.80-1.70	—	1.70-2.30	0.18-0.35	—	3.70-4.30	0.10	0.05	0.15	Remainder

[1] *Composition in % maximum unless shown as a range.*
[2] *Electrical conductor metal.*
[3] *No. 1 Reflector Sheet.*
[4] *Cladding on No 2. Reflector Sheet.*
[5] *Cladding on Alclad 2024.*
[6] *Also contains 0.20-0.6% each of lead and bismuth.*
[7] *Cladding on Alclad 2014.*
[8] *45 to 65% of magnesium content.*
[9] *Cladding on Alclad 5056.*
[10] *Cladding on Alclad 3003, Alclad 3004, Alclad 5050, Alclad 6061, and Alcad 7075.*
[11] *Cladding on Brazing Sheet.*
[12] *Aluminum percentage determined by difference.*

Source: Aluminum Association



sketch shows standard types of extruded shapes.

Commercial sizes range upward from 1/32 in. in thickness and up to 25 in. in widths. In special cases widths can range up to 60 in. Lengths vary from inches to over 80 ft. Maximum weight of extrusions, under optimum conditions, can reach 4200 lb. Many standard extruded shapes are available as stock items; however, where a particular design is needed the possibilities of designing a special die should be investigated. Die costs can range around $75 or $100 upwards, and this cost in many cases is comparatively low when considered in the light of costs of alternate methods of manufacture.

Tube

Lengths of small sizes of tube are limited by available fabricating equipment, though sizes up to 80 ft in length have been produced. Maximum commercial straight lengths are about 30 ft if subsequent thermal treatments are needed. Size of tube is controlled by outside diameter, inside diameter and wall thickness. It can be furnished to standard tolerances for any two, but not all three of these dimensions. It is obtainable in many shapes, including round, square, rectangular and tear-drop. Heavy-walled tube can be furnished with an inside taper.

Rolled shapes

Many shapes can be produced either by extruding or by a rolling operation. Large structural channels and I-beams too large to be extruded are produced by rolling. Where either process is applicable, the quantities required will often be the deciding factor. Specific information regarding size and availability of rolled shapes is available from producers.

Engineering Properties

There is no need to dwell on strength and elongation here. Accompanying tables tell the story rather completely, both for the various alloys at various tempers, and for the various alloys compared with other aluminum alloys. There are, however, some areas which should be stressed and explained more fully.

Property range

As has been mentioned before, a major advantage in using wrought aluminum is the wide range of mechanical properties obtainable. High purity aluminum (99.00-99.89%) and super purity aluminum (99.90 minimum) are so soft in the annealed condition that they can be cut with a knife. On the other hand 7075-T6 has a yield strength twice that of structural steel. Choice of alloy in any mechanical property range depends on the form required and other characteristics desired. Generally, use of a non-heat-treatable alloy is advantageous wherever practicable, since cost of heat treatment is avoided. Likewise, should a heat-treatable alloy be required, use of the material in the —T temper should be considered.

In many applications fabrication of heat-treatable alloys can be carried out advantageously in the —W temper. Alloys are most ductile in this condition and can be most readily formed. Due to the instability of this "as-quenched" temper, however, natural aging alloys in this condition must be formed immediately or kept under refrigeration until they are formed to prevent aging and subsequent strengthening. As well as the ductility of the material, an additional advantage is gained by forming in the —W temper such natural aging alloys as 2017 and 2024, in that no subsequent artificial aging treatment is required. In the —W condition these alloys require only exposure at room temperature for several days to develop their full natural aged strength.

Weight and rigidity

Specific gravity of commercially pure aluminum (1100) is 2.71, corresponding to a weight of 0.0979 lb per cu in. For design purposes the figure 10,500,000 psi is generally used as the average Young's modulus of elasticity for most wrought aluminum alloys. Young's modulus for steel is roughly three times this value, thus a section of aluminum will deflect or stretch three times as much as a similar section of steel under identical load conditions.

On an equal weight basis, aluminum alloys deflect about 1/7 as much as steel. For equal deflection, weight for aluminum is approximately one-half that for steel. Similar comparisons hold true for critical loads on long columns. The increased deflection

TYPICAL MECHANICAL PROPERTIES[1]

Alloy and Temper	Strength, psi		Elongation in 2 In., %		Brinell Number, 500 Kg Load 10mm Ball	Shearing Strength, psi	Endurance[2] Limit, psi	Modulus[3] of Elasticity, 10^6 psi
	Ultimate	Yield, 0.2% offset	1/16 in. Thick Specimen	1/2 in. Dia Specimen				
EC-0[4]	12,000	4000	—	—[5]	—	8000	—	10.0
EC-H12	14,000	12,000	—	—	—	9000	—	10.0
EC-H14	16,000	14,000	—	—	—	10,000	—	10.0
EC-H16	18,000	16,000	—	—	—	11,000	—	10.0
EC-H19	27,000	24,000	—	—[6]	—	15,000	7000	10.0
1100-0	13,000	5000	35	45	23	9000	5000	10.0
1100-H12	16,000	15,000	12	25	28	10,000	6000	10.0
1100-H14	18,000	17,000	9	20	32	11,000	7000	10.0
1100-H16	21,000	20,000	6	17	38	12,000	9000	10.0
1100-H18	24,000	22,000	5	15	44	13,000	9000	10.0
2011-T3	55,000[7]	43,000[7]	—	15	95	32,000	18,000	10.2
2011-T8	59,000	45,000	—	12	100	35,000	18,000	10.2
2014-0	27,000	14,000	—	18	45	18,000	13,000	10.6
2014-T4	62,000	42,000	—	20	105	38,000	20,000	10.6
2014-T6	70,000[8]	60,000[8]	—	13	135	42,000	18,000	10.6
Alclad 2014-0	25,000	10,000	21	—	—	18,000	—	10.5
Alclad 2014-T3	63,000[9]	40,000[9]	20	—	—	37,000	—	10.5
Alclad 2014-T4	61,000[9]	37,000[9]	22	—	—	37,000	—	10.5
Alclad 2014-T6	68,000[9]	60,000[9]	10	—	—	41,000	—	10.5
2017-0	26,000	10,000	—	22	45	18,000	13,000	10.5
2017-T4	62,000	40,000	—	22	105	38,000	18,000	10.5
2018-T61	61,000	46,000	—	12	120	39,000	17,000	10.8
2024-0	27,000	11,000	20	22	47	18,000	13,000	10.6
2024-T3	70,000	50,000	18	—	120	41,000	20,000	10.6
2024-T4	68,000[8]	47,000[8]	20	19	120	41,000	20,000	10.6
2024-T36	72,000	57,000	13	—	130	42,000	18,000	10.6
Alclad 2024-0	26,000	11,000	20	—	—	18,000	—	10.6
Alclad 2024-T3	65,000[10]	45,000[10]	18	—	—	40,000	—	10.6
Alclad 2024-T4	64,000[10]	42,000[10]	19	—	—	40,000	—	10.6
Alclad 2024-T36	67,000[10]	53,000[10]	11	—	—	41,000	—	10.6
Alclad 2024-T81	65,000[10]	60,000[10]	6	—	—	40,000	—	10.6
Alclad 2024-T86	70,000[10]	66,000[10]	6	—	—	42,000	—	10.6
2117-T4	43,000	24,000	—	27	70	28,000	14,000	10.3
2218-T72	48,000	37,000	—	11	95	30,000	—	10.8
3003-0	16,000	6000	30	40	28	11,000	7000	10.0
3003-H12	19,000	18,000	10	20	35	12,000	8000	10.0
3003-H14	22,000	21,000	8	16	40	14,000	9000	10.0
3003-H16	26,000	25,000	5	14	47	15,000	10,000	10.0
3003-H18	29,000	27,000	4	10	55	16,000	10,000	10.0
Alclad 3003-0	16,000	6000	30	40	—	11,000	—	10.0
Alclad 3003-H12	19,000	18,000	10	20	—	12,000	—	10.0
Alclad 3003-H14	22,000	21,000	8	16	—	14,000	—	10.0
Alclad 3003-H16	26,000	25,000	5	14	—	15,000	—	10.0
Alclad 3003-H18	29,000	27,000	4	10	—	16,000	—	10.0
3004-0	26,000	10,000	20	25	45	16,000	14,000	10.0
3004-H32	31,000	25,000	10	17	52	17,000	15,000	10.0
3004-H34	35,000	29,000	9	12	63	18,000	15,000	10.0
3004-H36	38,000	33,000	5	9	70	20,000	16,000	10.0
3004-H38	41,000	36,000	5	6	77	21,000	16,000	10.0
Alclad 3004-0	26,000	10,000	20	25	—	16,000	—	10.0
Alclad 3004-H32	31,000	25,000	10	17	—	17,000	—	10.0
Alclad 3004-H34	35,000	29,000	9	12	—	18,000	—	10.0
Alclad 3004-H36	38,000	33,000	5	9	—	20,000	—	10.0
Alclad 3004-H38	41,000	36,000	5	6	—	21,000	—	10.0

(See footnotes at end of table, p. 117)

(by volume of aluminum alloys) caused by lower moduli of elasticity, is offset by the better ability of aluminum to absorb impact without permanent set, and to reduce stresses produced by fixed deflections. Their ability to absorb energy from dynamic loads is even greater. For example, for equal elastic strengths, the strong aluminum alloys will absorb approximately eight times as much energy as steel, on a weight basis. By volume, the energy absorption of aluminum is three times that of steel.

Elevated temperature properties

One of aluminum's limitations is its relatively poor heat resistance. At elevated temperatures, alloys have lower tensile, yield and compressive strengths, moduli of elasticity, and a higher elongation. Decline in strengths are noticeable for low strength alloys starting at around 300 F. In the range of 300-500 F, use of aluminum alloys is problematic, depending on requirements. Of course, some alloys are better than others. For instance, after 1000 hr at 500 F, 2218 in the —T6 condition retains a tensile strength of 13,000 psi, yield strength of 9000 psi and elongation of 50%. After 1000 hr at 600 F, it retains a tensile strength of 6000 psi, yield of 3500 psi and elongation of 75%.

Fatigue values for several alloys illustrate the decline in strength of aluminum at elevated temperatures. At 500,000,000 cycles of reversed stress at a test temperature of 300 F, 2014-T6 has a fatigue strength of 12,000 psi, 2024-T4 has a fatigue strength of 14,000 psi and 7075-T6 has a fatigue strength of 12,000 psi. Under the same conditions at 500 F, 2014-T6 has a fatigue strength of 5000 psi, 2024-T4 has a value of 6000 psi, and 7075-T6 has a value of 7000 psi.

New alloys under develcpment indicate that improvements are feasible at least at temperatures up to 500 or 600 F. The alloy X2219, presently available in experimental quantities, is said to retain a tensile strength after 1000 hr at 500 F of 29,000 psi, yield strength of 21,000 psi and elongation of 24%. After 1000 hr at 600 F the alloy retains a tensile strength of 18,000 psi, yield

of 14,000 psi and elongation of 26%. Prospects for stressed applications of aluminum at temperatures above 500 or 600 F are dim indeed.

At sub-zero temperatures, on the other hand, tensile and yield strengths and elongation of aluminum alloys all increase. For instance, 2024-T4 at room temperature has a tensile strength of 69,000 psi, and a yield strength of 45,000 psi. At −184 F tensile strength has increased to 76,000 psi and yield strength has gone up to 49,000 psi.

Hardness

Hardness tests on aluminum alloys should be used only for comparison between various alloys or as a control aid in heat treatment. Attempts to correlate hardness with strength, as is done with steels, have met with varying degrees of success. Ratio of tensile strength to Brinell hardness depends on the alloy, the degree of solution of soluble constituents and amount of cold work. Published hardness values have been obtained with a Brinell instrument employing a 10-mm ball and a 500 kg load. The Rockwell tester is preferred by many, and is extensively used in mill production. However, it is imperative that there be no anvil effect when testing thin gage material. The Vickers tester, the Barcol impressor and the Webster hardness gage are also used successfully for securing comparative values.

Electrical conductivity

Aluminum is well known for its high electrical conductivity. An aluminum bar or wire of the same length and cross-section as a copper bar or wire (made of 100% IACS copper) has 62% of the latter's conductance. On the other hand, an aluminum bar or wire whose length and weight are equal to those of a copper bar or wire has 213% of the latter's conductance. Electrical conductivities of alloys of aluminum depend largely on amount and type of alloying elements in solid solution. Undissolved or insoluble constituents exert only a minor effect.

Recently several aluminum producers announced the development of new alloys with an optimum compromise between con-

TYPICAL MECHANICAL PROPERTIES[1]

Alloy and Temper	Strength, psi		Elongation in 2 In., %		Brinell Number, 500 Kg Load 10mm Ball	Shearing Strength, psi	Endurance[2] Limit, psi	Modulus[3] of Elasticity, 10^6 psi
	Ultimate	Yield, 0.2% offset	1/16 in. Thick Specimen	½ in. Dia Specimen				
5005-0	18,000	6000	30	—	28	11,000	—	10.0
5005-H12	20,000	19,000	10	—	—	14,000	—	10.0
5005-H14	23,000	22,000	6	—	—	14,000	—	10.0
5005-H16	26,000	25,000	5	—	—	15,000	—	10.0
5005-H18	29,000	28,000	4	—	—	16,000	—	10.0
5005-H32	20,000	17,000	11	—	36	14,000	—	10.0
5005-H34	23,000	20,000	8	—	41	14,000	—	10.0
5005-H36	26,000	24,000	6	—	46	15,000	—	10.0
5005-H38	29,000	27,000	5	—	51	16,000	—	10.0
5050-0	21,000	8000	24	—	36	15,000	12,000	10.0
5050-H32	25,000	21,000	9	—	46	17,000	13,000	10.0
5050-H34	28,000	24,000	8	—	53	18,000	13,000	10.0
5050-H36	30,000	26,000	7	—	58	19,000	14,000	10.0
5050-H38	32,000	29,000	6	—	63	20,000	14,000	10.0
Alclad 5050-0	21,000	8000	24	—	—	15,000	—	10.0
Alclad 5050-H32	25,000	21,000	9	—	—	17,000	—	10.0
Alclad 5050-H34	28,000	24,000	8	—	—	18,000	—	10.0
Alclad 5050-H36	30,000	26,000	7	—	—	19,000	—	10.0
Alclad 5050-H38	32,000	29,000	6	—	—	20,000	—	10.0
5052-0	28,000	13,000	25	30	45	18,000	17,000	10.2
5052-H32	33,000	28,000	12	18	62	20,000	18,000	10.2
5052-H34	38,000	31,000	10	14	67	21,000	18,000	10.2
5052-H36	40,000	35,000	8	10	74	23,000	19,000	10.2
5052-H38	42,000	37,000	7	8	85	24,000	19,000	10.2
5056-0	42,000	22,000	—	35	65	26,000	20,000	10.3
5056-H18	63,000	59,000	—	10	105	34,000	22,000	10.3
5056-H38	60,000	50,000	—	15	100	32,000	22,000	10.3
5086-0	38,000	17,000	22	—	—	23,000	—	10.3
5086-H32	42,000	30,000	12	—	—	—	—	10.3
5086-H34	47,000	37,000	10	—	—	27,000	—	10.3
5086-H112	39,000	19,000	14	—	—	—	—	10.3
5154-0	35,000	17,000	27	—	58	22,000	17,000	10.2
5154-H32	39,000	30,000	15	—	67	22,000	18,000	10.2
5154-H34	42,000	33,000	13	—	73	24,000	19,000	10.2
5154-H36	45,000	36,000	12	—	78	26,000	20,000	10.2
5154-H38	48,000	39,000	10	—	80	28,000	21,000	10.2
5154-H112	35,000	16,000	25	—	63	—	17,000	10.2
5357-0	19,000	7000	25	—	32	12,000	—	10.0
5357-H32	22,000	19,000	9	—	40	13,000	—	10.0
5357-H34	25,000	22,000	8	—	45	15,000	—	10.0
5357-H36	28,000	26,000	7	—	51	17,000	—	10.0
5357-H38	32,000	30,000	6	—	55	18,000	—	10.0
6061-0	18,000	8000	25	30	30	12,000	9000	10.0
6061-T4	35,000	21,000	22	25	65	24,000	14,000	10.0
6061-T6	45,000	40,000	12	17	95	30,000	14,000	10.0
Alclad 6061-0	17,000	7000	25	—	—	11,000	—	10.0
Alclad 6061-T4	33,000	19,000	22	—	—	22,000	—	10.0
Alclad 6061-T6	42,000	37,000	12	—	—	27,000	—	10.0
6062-0	18,000	8000	—	30	30	12,000	9000	10.0
6062-T4	35,000	21,000	—	25	65	24,000	14,000	10.0
6062-T6	45,000	40,000	—	17	95	30,000	14,000	10.0
6063-0	13,000	7000	—	—	25	10,000	8000	10.0
6063-T4	25,000	13,000	22	—	—	—	—	10.0
6063-T5	27,000	21,000	12	—	60	17,000	10,000	10.0
6063-T6	35,000	31,000	12	—	73	22,000	10,000	10.0

TYPICAL MECHANICAL PROPERTIES[1]

Alloy and Temper	Strength, psi		Elongation in 2 In., %		Brinell Number, 500 Kg Load 10mm Ball	Shearing Strength, psi	Endurance[2] Limit, psi	Modulus[3] of Elasticity, 10^6 psi
	Ultimate	Yield, 0.2% offset	1/16 in. Thick Specimen	1/2 in. Dia Specimen				
6063-T42	22,000	13,000	20	—	42	14,000	9000	10.0
6063-T83	37,000	35,000	9	—	82	22,000	—	10.0
6063-T831	30,000	27,000	10	—	70	18,000	—	10.0
6063-T832	42,000	39,000	12	—	95	27,000	—	10.0
6066-0	22,000	12,000	—	18	43	—	—	10.0
6066-T4	52,000	30,000	—	18	90	—	—	10.0
6066-T6	57,000	52,000	—	12	120	—	—	10.0
7001-0	37,000	22,000	—	14	60	—	—	—
7001-T6	98,000	91,000	—	9	160	—	—	—
7075-0	33,000	15,000	17	16	60	22,000	—	10.4
7075-T6	83,000[11]	73,000[11]	11	11	150	48,000	23,000	10.4
Alclad 7075-0	32,000	14,000	17	—	—	22,000	—	10.4
Alclad 7075-T6	76,000	67,000	11	—	—	46,000	—	10.4

[1] These typical properties are average for various forms, sizes and methods of manufacture, and may not exactly describe any one particular product.
[2] Based on 500,000,000 cycles of completely reversed stress using the R. R. Moore type of machine and specimen.
[3] Average of tension and compression moduli. Compression modulus is about 2% greater than tension modulus.
[4] Electrical conductor grade, 99.45% of minimum aluminum.
[5] EC-O wire will have an elongation of approximately 23% in 10 inches.
[6] EC-H19 wire will have an elongation of approximately 1½% in 10 inches.
[7] Sizes greater than 1½ in. will have strengths slightly lower than these values.
[8] Extruded products more than ¾ in. thick will have strengths 15 to 20% higher than these values.
[9] Sheet less than .040 in. thick will have strengths slightly lower than these values.
[10] Sheet more than .062 in. thick will have strengths slightly higher than these values.
[11] Extruded products will have strengths approximately 10% higher than these values.

Source: Aluminum Association

ductivity and strength. Designated 6101 and 2EC, they have a minimum tensile strength of about 29,000 psi, yield strength of about 25,000 and a minimum conductivity of about 57% IACS. According to producers, compressive creep characteristics are improved over those of standard EC grade aluminum.

Interesting possibilities derive from the fact that the oxide film formed on aluminum and all its alloys has good electrical insulating qualities. By building up this film, an effective insulation is provided and an aluminum conductor can provide its own insulation.

Corrosion resistance

Aluminum has a high affinity for oxygen, and when exposed to air quickly forms a thin protective aluminum oxide film, about 0.0000005 in. thick. The film prevents further oxidation or attack unless it is removed or penetrated by chemical or mechanical means. The resistance of aluminum to attack by various corrosive media is thus measured by the resistance of the oxide film to the corrodants. Thickness of the oxide film can be increased by chemical and electrochemical means to improve protection.

Galvanic attack—Where another metal must be used against aluminum it is desirable to select one which is electronegative or anodic to aluminum, and which will act as a sacrificial anode, preventing galvanic corrosion of the aluminum. Alclad materials obtain their high resistance to corrosion by galvanic protection, since the cladding material chosen is electronegative or anodic to the core alloy. Any galvanic attack that occurs first affects the cladding, and does not penetrate the core until large areas of the cladding have been removed.

Chromium, magnesium, silicon and manganese either increase or have no appreciable detrimental effect on corrosion resistance of aluminum alloys. Iron, copper and tin decrease aluminum's resistance to corrosion unless corrective elements are present.

Any of the high copper alloys become susceptible to intergranular corrosion when subjected to an improper quench. Quenching can be too slow or delayed; with some alloys, heating to critical temperatures after quenching might cause susceptibility. The high copper alloys in the annealed condition are susceptible to intergranular corrosion and should always be heat treated.

Chemical attack — Aluminum and its alloys are resistant to attack by many chemicals and foods. Even when slightly affected, corrosion products are colorless and nontoxic. Though there are also many chemicals that severely attack aluminum, use of the proper inhibitors such as sodium silicate or sodium chromate permits use of aluminum with many of these materials.

Dilute solutions of most mineral acids attack aluminum to some extent. Concentrated (above 80% by wt) and dilute (5% or less) nitric acid have negligible effects on high purity aluminum, and on alloys 1100 and 3003. Attack by sulfuric acid is somewhat greater than with nitric acid, though 1100 and 3003 alloys are used in solutions containing as much as 5% sulfuric. Fuming sulfuric acid has a low rate of attack, but combined with any appreciable amount of water or water vapor it has a serious effect. All strengths of boric acid solutions have limited effect on aluminum. Weak solutions (less than 5%) of chromic acid have little effect but the rate of attack is excessive for concentrations over 10%.

Simple organic acids, such as acetic, citric, lactic and tartaric, in conjunction with slight amounts of water do not react with aluminum. Likewise, fatty acids, such as stearic, have a low rate of attack if any water is present. Simple acids that contain a halogen radical, and formic and oxalic acids are too corrosive for most applications.

Strong caustic solutions attack rapidly, while weak solutions containing chemical inhibitors have a low rate of attack and can be used if certain precautions are taken. Ammoniacal solutions have little corrosive effect after building up a protective surface film on the metal.

Salts composed of strong acid radicals (except the halogens)

TYPICAL PHYSICAL PROPERTIES

Alloy	Density, lb/cu ft	Avg coef of Therm Exp, 68 to 212 F	Melt Range (approx), F	Temper	Therm Cond at 77 F, Btu	Elec Cond at 68 F, % of IACS		Elec Resist at 68 F, Ohms/mil-ft
						Equal Vol	Equal Wt	
EC	169	13.2	1195-1215	All	1625	62	204	17
1100	169	13.1	1190-1215	—0	1540	59	194	17
				—H18	1510	57	187	18
2011	176	12.7	995-1190	—T3	990	36	113	29
2014	175	12.8	950-1180	—0	1340	50	159	21
				—T4	840	30	95	35
				—T6	1070	40	127	26
2017	174	13.1	955-1185	—0	1190	45	143	23
				—T4	840	30	96	35
2018	175	12.4	948-1180	—T61	1070	40	127	26
2024	173	12.9	935-1180	—0	1310	50	160	21
				—T3, T4, T36	840	30	96	35
2117	171	13.2	950-1200	—T4	1070	40	130	26
2218	176	12.4	940-1175	—T72	1070	40	126	26
3003	170	12.9	1190-1210	—0	1340	50	163	21
				—H12	1130	42	137	25
				—H14	1100	41	134	25
				—H18	1070	40	130	26
3004	170	13.3	1165-1205	All	1130	42	137	25
5005	169	13.2	1170-1205	All	1390	52	172	20
5050	168	13.2	1160-1205	All	1340	50	165	21
5052	167	13.2	1100-1200	All	960	35	116	30
5056	165	13.5	1055-1180	—0	810	29	98	36
				—H38	750	27	91	38
5086	166	—	1084-1184	All	870	31	104	34
5154	166	13.3	1100-1190	All	870	32	107	32
5357	169	13.2	1165-1210	All	1160	43	142	24
6061	169	13.1	1080-1200	—0	1190	45	148	23
				—T4, T6	1070	40	132	26
6062	169	13.1	1100-1205	—0	1190	45	148	23
				—T4, T6	1070	40	132	26
6063	169	13.0	1140-1205	—T5, T6	1390	53	175	20
				—T42	1340	50	165	21
7075	175	13.1	890-1180	—T6	840	30	95	35

Source: Aluminum Association

and weak base radicals usually have little effect on aluminum. Halogen-bearing salts, such as ammonium chloride, are corrosive unless used in conjunction with an inhibitor. Ammonium nitrate and ammonium sulfate can be handled satisfactorily. Salts composed of weak acid radicals and strong base radicals, which hydrolyze to give alkaline solutions, should not be used with aluminum except with suitable inhibitors, such as sodium or potassium chromate or sodium silicate.

When aqueous solutions or liquids containing small amounts of water, contaminated with heavy metals or their salts, come in contact with aluminum a localized pitting type of corrosion can occur. This can be controlled by adding corrosion inhibitors, or by using alclad alloys.

Forming Aluminum

Aluminum and its alloys, being among the most workable of the metals, are well suited to nearly all kinds of forming operations. In sheet form they can be blanked, pierced, drawn, stretched, enclosed, coined, stamped, spun, bent, rolled, flanged, beaded, curled, crimped and hammered. In the form of blanks or bar stock, they can be extruded, forged, upset and machined.

Sheet metal forming and drawing

Depending upon depth, drawing operations range from mild to very severe cold working, and alloys and tempers should be selected accordingly. For severe draws the annealed (—0) temper should be used. Less severe draws can be made on the non-heat-treatable alloys in various cold-worked tempers, on 2014 in the –W or –T4 temper, on 6061 in the –T4 temper, on 7075 and 2024, with or without cladding, in the –W temper. Aging treatment, following drawing, can be used to produce the desired temper in the finished part.

Cold working in drawing increases strength and decreases elongation of alloys. For example, after four draws the tensile strength of 3003 is increased from 16,000 to over 24,000 psi, while elongation is reduced from 30 to 7.5% in 2 in. After four draws, the tensile strength of 5052 is increased from 29,050 to 43,750 psi, while elongation is reduced from 27 to 6% in 2 in. Of course, it is desirable from the standpoint of costs to draw a shape with as few draw steps as possible. Therefore, the initial draw should be the maximum possible with that alloy, which is dependent on the ratio of sheet thickness to blank diameter.

Selecting suitable bend radii is an important factor in forming aluminum alloys. An accompanying table lists minimum recommended bend radii for various alloys. It should be remembered that material must be stressed beyond its yield strength in order to permanently form it to a desired shape or contour, otherwise it will tend to return to its origi-

nal shape. Though very little spring-back is encountered when forming materials in the –0 condition, it will occur when forming tempered sheet. Since exact amounts of spring-back are difficult to compute, tools should be adjusted for over-bending unless preliminary experiments have accurately established spring-back characteristics.

Due to its good cold formability, aluminum alloy sheet is being widely formed by many of the newer short run forming methods, employing a flexible die member. Aluminum parts, even in limited quantities, can be produced economically by the Guerin process, which utilizes a rubber press pad in place of a female die member, or by Hydroform or Marform processes, which use a combination of rubber diaphragms and hydraulic pressures, or by the Hydrodynamic process, which uses soluble oil or water under pressure to replace the male die member. Sheet aluminum can also be economically formed by drop hammer. A great deal of successful forming has been done by aircraft companies using a male drop hammer punch and a rubber press pad to replace the female die member.

Though a great deal of aluminum sheet forming is done at room temperature, there are some applications where use of heat can provide definite advantages. Such is the case in stretch forming some of the high strength alloys. Heating to 650 F does not harm the annealed temper of any alloy, though materials in the strain-hardened tempers, of course, lose a great deal of their strength. Exposure of the magnesium-silicide type heat-treated alloys to high temperatures can cause a loss in mechanical properties, but does not appreciably affect resistance to corrosion. Exposure of high copper alloys in the –W or –T conditions can impair mechanical properties and make them susceptible to serious intergranular corrosion.

Several aluminum alloys can be cold spun economically. In order of increasing cost, they are 1100–0, 3003–0, 6061–0, 5052–0 and 2024—0.

Forgings

Die forgings and hot pressings in a wide range of sizes are available in 1100, 3003, 4032, and the heat-treatable alloys 2014, 2018, 2025, 6061, 6066, 6151, and 7075. Hand forging is done, but the bulk of production is in die forgings where quantity is sufficient to justify cost of a special die. Feasibility of producing any special design as a forging is best determined through the producers.

Since the reason for using forgings is to obtain the high strength and ductility characteristics of wrought alloys, design must take into consideration flow of metal in passing from billet to finished forging. Shape of a die forging must be such that it can be formed by a pair of dies. That is, it must be such that a parting line can be established. Sharp angles are to be avoided, and draft is normally necessary to permit removal of piece from the die, though several companies have now developed techniques which can eliminate need for draft.

2014 is the most widely used of the aluminum forging alloys. 6151 has the optimum in forgeability and excellent machinability. 7075 is an extremely high strength material, which is more difficult to work than other alloys. 4032, 2218 and 2018 resist high stresses at elevated temperatures. They also have high thermal conductivity and low coefficient of thermal expansion. 6061 is specified only for its superior welding and brazing qualities. 2025 is a special-purpose alloy used for air-

MINIMUM BEND RADII FOR ALUMINUM SHEET

The minimum allowable radii for bending aluminum alloy sheet depends on the thickness, temper and composition of the material. Values given in the table are for 90-deg bends. For bends greater than 90 deg, the bend radii should be increased.

Gage	7075-0 **7075-W	7075-T6	2024-0 *2024-W 2014-0	2014-T3 or 2014-T3	2024-T3 2014-T6	6061-0	6061-T4	6061-T6
0.020	1/32	3/32	1/64	1/16	1/16	0	1/32	1/32
0.025	1/32	1/8	1/64	1/16	3/32	0	1/32	1/32
0.032	1/16	5/32	1/64	1/16	3/32	0	1/32	1/32
0.040	1/16	3/16	1/32	3/32	1/8	0	1/32	1/32
0.051	3/32	1/4	1/16	1/8	3/16	0	1/16	1/16
0.064	1/8	5/16	1/16	5/32	7/32	0	1/16	3/32
0.081	5/32	3/8	3/32	7/32	9/32	0	3/32	1/8
0.091	3/16	1/2	3/32	1/4	11/32	0	1/8	5/32
0.102	3/16	5/8	3/32	5/16	7/16	0	1/8	3/16
0.125	7/32	3/4	1/8	3/8	1/2	1/16	3/16	1/4
0.156	3/8	1	5/32	7/16	5/8	1/8	5/16	5/16
0.187	1/2	1 1/4	3/16	1/2	3/4	3/16	3/8	9/16

Gage	5052-0	5052-H32 1/4 Hard	5052-H34 1/2 Hard	5052-H38 3/4 Hard	5052-H38 Hard	1100-H12 1/4 Hard	1100-H14 1/2 Hard	1100-H16 3/4 Hard	1100-H18 Hard
0.020	0	0	0	1/32	1/32	0	0	0	1/32
0.025	0	0	0	1/32	1/32	0	0	0	1/32
0.032	0	0	0	1/32	1/16	0	0	0	1/32
0.040	0	0	0	1/16	1/16	0	0	0	1/16
0.051	0	0	1/32	1/16	3/32	0	0	1/32	1/16
0.064	0	0	1/16	3/32	1/8	0	0	1/16	3/32
0.081	0	1/32	1/16	1/8	3/16	1/32	1/32	1/16	1/8
0.091	0	1/16	3/32	1/8	1/4	1/16	1/16	3/32	1/8
0.102	0	3/32	1/8	3/16	5/16	3/32	3/32	1/8	3/16
0.125	0	1/8	1/8	1/4	3/8	1/8	1/8	1/8	1/4
0.156	0	5/32	3/16	1/2	5/8	5/32	5/32	3/16	1/2
0.187	0	3/16	9/32	9/16	3/4	3/16	3/16	9/32	9/16

* (2024-W) *Freshly quenched and formed within 1/2 hr max or 24 hr max if iceboxed at 32F.*
** (7075-W) *Freshly quenched and formed within 2 hr max or 24 hr max if iceboxed at 32 F.*

craft propellers, impellers for combustion turbines and similar type parts. X7079 is a new high strength alloy developed to provide higher and more uniform properties than 7075 in sections over 3 in., and greater ductility in cross-grained directions.

Impact extrusions

Though aluminum impact extrusions were originally limited to high purity aluminum and the softer alloys, they are now being produced in the strong alloys such as 6061 and 7075. Difficulty has been due to the fact that at room temperature, extrusion pressures increase in nearly a direct relationship with tensile strengths. Now, however, parts are in production from almost a dozen aluminum alloys including 2014, 3003, 6053, 6061, 6063, 6066, 6151, 7001, and 7075.

Parts are produced as forward extrusions, backward extrusions, and double extrusions. Forward extrusions have been produced up to 80 in. long, and backward up to 18 in., by the impact extrusion method. For the high strength alloys, recommended minimum thickness of flange or bottom is 0.125 in. Tolerances on parts are comparable with machined parts and surface finish ranges from 40 to 250 rms.

Machining

Most wrought aluminum alloys are readily machinable, though those containing large amounts of free silicon are abrasive in their action on the tool and should be machined with cemented carbide tools. Under ideal conditions, free-machining alloys will machine ten times faster than steel.

In comparison with steel, larger rake angle, both top and side, should be used for cutting aluminum. Cutting surfaces should have a top rake between 20 and 50 degrees, and a side rake of 10 to 20 degrees. Smooth finish of the cutting surface and a sharp burr-free edge are important to satisfactory cutting. Plain carbon steel tools are satisfactory for low-speed cutting, particularly for drilling. Elsewhere high-speed tool steels are preferred, except where cemented carbide tools are recommended, such as in machining alloys with large amounts of free silicon. These principles apply to nearly all types of tools, including those for lathes, shapers, and milling machines, and including taps, drills and saws.

Chemical forming

Two interesting techniques recently developed for forming metals by chemical etching lend themselves to forming aluminum. One process called Chemi-Cut (MATERIALS & METHODS, Mar., 1955, p. 96) makes use of selective etching by an acid to produce parts ordinarily produced by routing or stamping. Primary advantages seem to lie in cost reduction through elimination of labor and handling, increase in flexibility and complexity of design possibilities, reduction in quantity of material used, and high degree of reproducibility. Maximum thickness of sheet material is 0.040 in. for two-stage etch and 0.020 in. for one-stage etch.

The other process, Chem-Milling (MATERIALS & METHODS, Oct., 1954, p. 89), is said to provide a low cost method of milling sheet, forgings or extrusions. Differential metal removal is obtained by removing masking at varying times or altering the speed of immersion or removal of metal from solution. Advantages claimed for the method include: 1) can be done after forming; 2) design is not subject to restrictions on shape of cut, direction of cut and limiting radii imposed by machining; 3) metal can be removed from both sides simultaneously; 4) stiffening members can be incorporated in a design without joining operations; 5) taper can be readily controlled and various depths of cut can be obtained in one operation; 6) tolerances of 0.002 in. on thickness can be held.

Joining Aluminum

Wrought aluminum alloys can be joined by most commercial metal-fastening methods. Mechanical methods, including riveting, stapling and adhesive bonding are used with sheet aluminum. Welding and brazing can be used with sheet and solid sections, such as forgings, rod, bar and extrusions. Soldering, which presents particular problems with aluminum, can be used with sheet alloys.

Mechanical fastening

Riveting is probably the most popular method of fastening aluminum sheet, because it provides a relatively inexpensive method of obtaining a strong permanent joint. Choice of the proper rivet alloy depends on the alloy of the sheets being joined and driving characteristics desired. Rivets are available in alloys 1100, 2024, 2117, 5056, 6053, 6061 and 7277, in various tempers. They are usually used for joining the following sheet alloys:

1100—Used for joining 1100, 3003–0 3004–0 5050–0 5052–0.

2117—Used for joining hard tempers of 3003 and 5052; also 2014, 2017, 2024, 7075.

2017 and 2024—Used for joining 2014, 2017, 2024, 7075.

5056—Used for joining magnesium alloys.

As can be seen from above, aluminum rivets for a particular job should have about the same strength as the material being joined. When riveting, aluminum rivets should always be used to join aluminum to prevent galvanic corrosion. Steel rivets may be used on some heavy structural parts, but they should never be used in presence of an electrolyte, unless adequate paint protection is provided.

Screw fasteners, also widely used for joining aluminum parts can be made from any aluminum alloy, though most are of 2024 because of its high tensile and shear strengths. When another fastener must be substituted for aluminum, cadmium plated steel fasteners are the best alternative, though galvanized fasteners can be used under some conditions.

Metal stitching or stapling, using either pre-formed staples, or machines which form their own staples, is being more and more widely used for joining thin sheet

alloys. It provides high speed of application, requires less-skilled workers, and precludes the need for backing strips, pre-punched or drilled holes and clamping.

There has been an increasing amount of interest evinced recently in adhesive bonding of aluminum. That is, joining aluminum either to itself or to dissimilar materials by natural and synthetic adhesives applied under relatively low heat and pressures. Adhesive bonding is advantageous in that: 1) it allows joining of dissimilar metals; 2) it eliminates need for high temperatures during joining, and piercing of materials; 3) provides leak-proof joints; 4) provides uniform stress distribution and increased service life with reduced weight and smooth surfaces and contours; and 5) provides insulation and vibration-damping properties and corrosion resistance.

Impetus to adhesive bonding has been provided by the refinements of resins such as phenolics and epoxies, and of formulations such as phenolic-vinyl, phenolic-polyvinyl butyral, phenolic- polyvinyl formal and phenolic-Buna-N.

Welding

Developments in both technique and equipment now permit welding of heat-treatable as well as the non-heat-treatable alloys. Due to continual process development, aluminum is now about as easy to weld and as generally weldable as steel. There are several welding methods used successfully. The following sections briefly outline their applicability to aluminum.

Gas welding—Oxyacetylene or oxyhydrogen welding (usually with filler metal) was the pioneer method of welding aluminum and is extensively used today. It is applicable to sections 0.032 in. or more in thickness, particularly where gas-tight welds are required.

Important points to watch are preheating and choice of the proper flux. In wrought materials, preheating up to 800 F is recommended for sections over ⅜ in. thick. Minimum distortion is obtained with edge or corner welds that permit the bead to be located on a crown or radius. Welded seams or fittings in flat areas should be avoided because of shrinkage stresses. When the proper flux is used, the oxide film on the aluminum combines with the flux at welding temperatures to form a slag, which comes to the surface of the weld. Any excess flux left after welding should be cleaned off immediately with boiling water or steam, or by immersion in cold dilute nitric acid or a warm 5% sulfuric acid solution.

Arc welding with flux—Metal arc, carbon arc and atomic hydrogen arc are three electric arc methods of welding aluminum employing a flux to remove the oxide film. Metal arc welding is useful for welding all aluminum alloys. Because of concentrated heat zone, cracking is minimized. However, the fact that weld soundness and smoothness of the surface are not as good as other arc welding methods, plus the necessity for using a flux, account for the process's decrease in popularity.

RELATIVE SUITABILITY FOR WELDING ALUMINUM[1]

Alloy	Gas	Arc with flux	Inert-gas arc	Resistance	Pressure	Brazing	Soldering
EC-O	A	A	A	B	A	A	A
1100-0	A	A	A	B	A	A	A
3003-0	A	A	A	B	A	A	A
3004-0	A	A	A	B	A	B	B
2011-T3	D	D	D	D	D	D	D
2014-T6	D	B	B	B	D	D	D
2017-T4	D	B	B	A	D	D	D
2024-T3	D	B	B	B	C	D	D
4032-T6	D	B	B	C	C	D	D
5050-0	A	A	A	B	A	B	B
6151-T6	A	A	A	A	C	B	B
6951-0	A	A	A	B	A	A	A
5052-0	A	A	A	B	A	C	C
6053-T6	A	A	A	A	C	A	B
5154-0	C	A	A	B	A	D	D
5154-H38	C	A	A	A	C	D	D
5056-0	C	A	A	B	A	D	D
6061-T6	A	A	A	A	C	A	B
6062-T6	A	A	A	A	C	A	B
6063-T5	A	A	A	A	C	A	B
7075-T6	D	D	D	B	D	D	D
Alclad 7075-T6	D	D	D	B	D	D	D

[1] *Weldability ratings A, B, C and D are relative ratings defined as follows:*

A. Generally weldable by all commercial procedures and methods.

B. Weldable with special technique or on specific applications which justify preliminary trials or testing to develop welding procedure and weld performance.

C. Limited weldability because of crack sensitivity or loss in resistance to corrosion and mechanical properties.

D. No commonly used welding methods have so far been developed.

Source: Welding Alcoa Aluminum, Aluminum Co. of America

Adaptations of carbon arc for automatic welding of long seams employ a bare filler wire with powdered flux supplied along with the wire. Carbon arc provides a more concentrated heat source than a gas torch flame, thus permitting faster welding with less distortion. Weld soundness is excellent, comparable to that of good gas welding. Here again, inert gas shielded arc welding has decreased the popularity of carbon arc welding, and though the latter may be expected to continue to fill certain needs, it does not occupy the important place it held during development of aluminum welding.

In the wrought aluminum field, atomic hydrogen welding is primarily used for rapid welding of fairly thin aluminum sheet. Where required, filler metal may be furnished by feeding a lightly fluxed rod into the molten pool. The gaseous envelope around the weld does not entirely preclude need for flux, but very little is needed. Flux residue must be cleaned off after welding. The major advantages of the method are speed, visibility of the pool of molten metal and ease of control over amount of heat applied and metal flow.

Inert-gas-shielded arc welding—Neither the inert-gas-tungsten arc nor the inert-gas-consumable electrode welding methods require flux. These processes represent one of the biggest advances in welding aluminum. The use of argon or helium to keep air away from the arc and the molten metal eliminates the need for flux and provides the following advantages: 1) welds do not have to be cleaned of residual flux; 2) inaccessible areas will not have any flux contamination to act as potential sources of corrosion; 3) welding can be done in all positions since there is no slag to be worked out of the weld by gravity or by puddling; 4) visual control is good since gas envelope is transparent and weld puddle clean; and 5) minimum distortion near the weld results from concentration of the heat.

Since there is no flux to take

up impurities, cleanliness is important. In some cases, design of the joint will provide enough parent metal so that filler metal is unnecessary. However, usually, filler metal is added, in bare rod form for hand welding or as a coil of wire for automatic feeding. Since the tungsten electrodes are non-consumable, a.c. current must be used.

Development of metal arc welding with a consumable, uncoated aluminum electrode in an inert gas atmosphere has significantly widened the application of welding aluminum alloys. It combines the same advantages as tungsten arc welding, with some unique virtues of its own. Arc energy is high, concentrating more heat than any of the other fusion welding methods. Problems of distortion, cracking and metallurgical change are reduced to minimum.

Resistance welding — Including both spot and seam welding, resistance welding is one of the most useful and practical methods of welding aluminum. Resistance welding is advantageous in that: 1) nothing is consumed except electric power; 2) process is fast; 3) almost entirely automatic; and 4) only small area of metal is heated, for minimum length of time, resulting in minimum metallurgical disturbance.

Good welds depend on a low and consistent surface resistance between the work pieces, therefore, surface oxides must not be heavy or non-uniform. They may be removed by various commercially prepared cleaners, hot caustic solutions, or by mechanical means. Welding does not have to be done immediately after removal. Pieces may be stored after cleaning for about 48 hr. The main requirement is cleanliness and consistency of the oxide film.

Flash welding—All wrought aluminum alloys can be flash welded and there are no inherent limitations on size or thickness of metal. Welds consist of narrow cast zone of weld metal on either side of which is a norrow zone of heat-affected and partially annealed metal. During the upsetting action, some hot working and some cold working occurs in the weld material and the heat-affected zone. Mechanical properties of joints are good both in the non-heat-treatable and the heat-treatable alloys. Joint efficiencies of at least 80% of that of the material in any temper can be expected, and efficiencies of 100% can be obtained on annealed alloys. Heat treating after welding does not improve strength very much, though it improves elongation substantially.

Pressure welding—Though there are few industrial applications for pressure welding in this country now, much interest has been shown in its potential for sheet fabrication, electrical connections, joining thin sheets or foil and for joining aluminum to other malleable metals. A weld can be achieved by bringing together two clean, smooth metal surfaces and applying pressure sufficient to decrease cross-sectional area by 50 to 75%. The softer metals that deform most readily provide optimum pressure welds. Thus joint efficiencies are greatest for non-heat-treatable alloys in the annealed condition. All non-heat-treatable aluminum alloys can be pressure welded in any of the standard tempers. Though heat-treated alloys can be pressure welded also, optimum joint strength is obtained if welding is done in annealed temper and parts are heat treated afterwards.

Pressure welding is being used for making lap welds in sheet and wire, and butt welds in tube, bar and wire stock. Copper-aluminum joints have been made successfully, but deformations of 60-70% are necessary for optimum welds.

JOINING ALUMINUM TO OTHER MATERIALS

	Ferrous alloys	Copper alloys	Nickel alloys	Magnesium alloys	Silver alloys	Precious metals	Zinc alloys	Lead alloys	Tin alloys	Com'l electroplates or hot dip coatings	Sintered graphite bronze	Titanium	Tungsten	Ceramics, glass, etc.	Plastics, wood, rubber, etc.
Torch welding	L	L	L	NR	—	—	—	—	—	—	NR	—	—	—	—
Arc welding	L	L	L	NR	—	—	—	—	—	—	—	—	L	—	—
Flash welding	NR	S	NR	NR	—	—	—	—	—	—	—	—	—	—	—
Resistance welding	L	NR	—	NR	—	—	—	—	—	—	—	—	—	—	—
Brazing	S	L	L	NR	—	—	—	—	—	L	NR	L	—	L	—
Transition joints	L	L	L	—	—	—	—	—	—	—	—	L	—	—	—
Hard soldering	S	S	L	L	L	—	L	—	—	L	NR	L	—	L	—
Soft soldering	S	S	S	L	S	S	S	S	S	S	NR	L	—	L	—
Diffusion welding	S	S	L	—	S	L	—	—	—	—	S	—	—	—	—
Pressure welding	S	S	L	—	L	L	S	L	L	—	—	—	—	—	—
Resin bonding	S	S	L	S	L	L	L	S	L	L	L	—	L	S	S

S —Satisfactory experience or quite easy.
NR —Not recommended.
L —Limited experience but possible.
— —No experience.

Source M. Miller, Aluminum Co. of America.

Brazing aluminum

Not all aluminum alloys can be brazed, as filler metals with a sufficiently low melting point have not been developed. Alloys that can be brazed are 1100, 3003, 3004, 6053, 6061, 6063, 5050, 6951, and 6062. Thus, heat-treatable alloys suitable for brazing may be described generally as being of the magnesium-silicide type. Higher strength wrought alloys such as those containing copper or zinc are not suitable for general purpose brazing by usual commercial practices. Standard brazing processes used with aluminum include torch, twin-carbon arc, furnace, induction, dip and block. Procedures for flow and resistance brazing have not as

yet been developed.

Filler metal for brazing aluminum is supplied in the form of wire or shims or in special sheets (brazing sheet) on which a uniform coating of filler metal is integrally bonded to the base metal. Round wire can be used in ring-form or as straight sections. In joining, lap joints rather than butt joints are generally used. However, in making any kind of joint, press or tight fits must be avoided in assembling to facilitate filler metal flow and minimize flux entrapment. Clearances up to 0.010 in. are suitable for joints with laps of less than ¼ in. long, while clearances up to 0.025 in. are used for longer laps.

Soldering aluminum

Though aluminum has not been considered to be a very solderable metal, the proper selection of flux or soldering method can provide joints the average strength of which will range from 5000 to 10,000 psi. The major problem is the aluminum oxide film which prevents solders from contacting the base metal. High purity aluminum is the easiest to solder. Next in line are alloys containing not more than 1% manganese or magnesium, and the heat-treatable alloys are the most difficult.

There are four basic methods of soldering aluminum; 1) friction or abrasion soldering, in which a pool of molten solder is deposited on the aluminum and the oxide is scratched off under the solder, allowing the molten metal to wet the abraded surface; 2) reaction solders, usually consisting of heavy metal chlorides; when heated, the chlorides react to form aluminum chloride which breaks up the oxide film allowing the heavy metal to wet the aluminum; 3) ultrasonic soldering which depends on cavitation erosion to break up the oxide film. Gas bubbles in the solder expand and contract with each ultrasonic vibration, building up forces sufficient to erode the film; and 4) an active flux which liberates an active reagent upon heating which, in turn attacks the oxide film allowing a layer of solder to be deposited on the aluminum.

The latter two methods are the newest and most promising. A recently developed tin-depositing stannous chloride flux seems promising. A dry powder, it melts at 380 F and becomes active at about 680 F, depositing tin on the aluminum surface and forming aluminum chloride which volatilizes, leaving no corrosive residue. A 70-30 zinc-tin solder when applied over the tin is said to offer the best combination of ease of application and strength. In lap joint tests on 3003 alloy joined in this manner, the parent metal failed before the joint.

The major development in ultrasonic soldering has been along the equipment line. Equipment has now been developed which offers portability and ease of use for shop soldering, and close control over frequency.

Finishes for Aluminum

Though aluminum by itself has a pleasing appearance, its ability to take a variety of finishes is one of its outstanding characteristics. This section consists only of a general outline of the various types of finishes feasible, along with an indication of the possibilities of each.

Mechanical finishing

Mechanical finishes are useful both for cleaning aluminum and for imparting a textured finish to the material. Buffing is probably the oldest and most common method of producing a bright finish with smooth reflective surface and high luster. Buffing includes polishing, tripoli buffing and color buffing. Mechanical abrasion, using abrasives and belts, cloth wheels and Tampico or wire brushes can produce satin finishes with directional properties and some sparkle. Obtaining the slight luster requires use of some lubricant such as tallow stick or oil. Tumbling is most often used for giving a bright finish to screw machine products, or it can be useful in deburring or finishing small stampings and small drawn parts of many different kinds.

Chemical finishes

Various types of chemical etching solutions are used to produce a diffuse satin, or frosted finish on aluminum. This type of finish is popular for decorative purposes and is functional in that it provides a diffuse reflecting surface for lighting fixtures. Caustic or acid solutions may be used. Acid solutions are milder in their attack than caustics and do not remove as much metal. All caustic etching should be followed by a thorough rinse in clean water at room temperature.

Chemical brightening treatments to obtain surfaces similar to those produced by electropolishing, at lower cost, are becoming increasingly popular. They are most useful in giving aluminum sheet pre-treatment preparatory to anodizing. Parts with irregular or curved surfaces which are expensive to polish mechanically are particularly well suited to polishing by this method.

Conversion coatings consisting of thin coatings of certain metals can be applied to aluminum by galvanic action in solutions of suitable compounds of the coating metal. The compounds react with the surface oxide film, removing the film and replacing it with a thin film of metal. Tin and brass coatings are used to reduce friction on pistons. Thin zinc films, deposited from a zincate solution are used as a base for electroplating, and silver coatings are used for electrically conductive surfaces in joints.

Several proprietary immersion coatings are available specifically designed to provide a suitable base for painting or finishing as well as providing improved corrosion resistance. Alrok (Aluminum Co. of America) finishes require about 30 min. to apply and consist of an oxide coating ranging from greenish-gray to almost black. Bonderite (Parker Rustproof Co.) and Alodine (American Chemical Paint Co.) require about 5 min. to apply and are mainly used as paint bases. Iridite No. 14 (Allied Research Products, Inc.) requires application times ranging up to 5 min, and provides a complex chromium-

chromate film which is not as hard as aluminum oxide films, but has low electrical resistivity and seems to provide a fluxing action for welding. Phosphate coatings, providing an adherent base for paints can be applied by dips of about 5 min. duration in phosphoric acid.

Electrolytic finishes

Electrolytically applied finishes for aluminum consist of electropolishing, anodizing and electroplating. Electropolishing and anodizing are combined in such processes as Alzak (Aluminum Co. of America) to provide a surface with high reflectance and permanence. There are a variety of anodizing treatments. Some use a chromic acid electrolyte, some a sulfuric acid electrolyte. The MHC Martin Hard Coat (Glenn L. Martin Co.) uses a sulfuric acid solution saturated with carbon dioxide to provide an exceptionally wear-resistant oxide film. The Sanford Process (Sanford Process Co., Inc.) is a hard anodizing treatment which provides a 6 mil coating in 55 min with a hardness of Rc50, a Moh scale hardness of about 8 and which will withstand up to 400 v.

Though anodic coatings are hard, they have a microscopic porosity which allows them to be colored by both organic and inorganic dyes. Though the dying of anodized coatings has been done for some time on fabricated aluminum parts, only recently have several companies announced availability of colored anodized sheet stock in continuous lengths. Thus, coiled sheet stock can be purchased already colored, and fabricated on mechanized forming machinery into finished products. Obvious advantages in mechanization of mass production and reduction of finishing costs result.

There are two main difficulties encountered in electroplating on aluminum. First of all, the oxide film must be removed and the metal plated directly on the aluminum, or on a conversion coating of another metal. Secondly, each alloy of aluminum has a different metallurgical structure. Alloying elements may be present in solid solution in aluminum lattice or as micro-particles of the elements themselves, or as particles of intermetallic compounds formed by combinations of alloying elements and aluminum. These various forms may have differing chemical and electro-chemical reactivities, resulting in an inconsistent reaction to the plating material across the surface of aluminum.

Both these problems have been solved by use of replacement coatings such as the zincate dip, which replaces the oxide film with a thin layer of zinc. A variety of electroplated coatings can be applied over the zinc. In some cases a copper flash is applied between the zinc and plate. Chromium can be plated for wear-resistance, tin for friction qualities, silver for electrical conductivity, or copper, nickel, cadmium, tin and silver for solderability.

Methods others than the zincate used for applying electroplates include the Work method, consisting of etching the surface to provide a mechanical locking action; phosphoric acid anodic process, providing adherent porous anodic coatings to which, and through which, plates such as nickel, cadmium, copper, silver and iron adhere; and wet blasting (usually used with chromium plating), consisting of wet blasting the aluminum with abrasive and water which removes dirt and the oxide film. Aluminum retains a thin film of the suspension long enough to prevent reformation of the oxide film until it is dipped in plating solution. The solution attacks the film, removing it and depositing chromium. Another process used for special applications consists of spraying electrically conductive rubber over aluminum, then plating chromium on the rubber. It is a time-consuming operation, but provides tough, relatively resilient coatings, such as are required for airplane propellers.

Enamels, lacquers and paints

Development of satisfactory vitreous enamels for aluminum has made rapid progress in recent years. The major problem has been to develop enamels with firing temperatures of 1000 F or less so as not to degrade the aluminum base. High lead frits are generally used, and enamels can now be applied which provide durability, corrosion resistance, thermal insulation, increased rigidity and color flexibility. Selection of alloy is important as only certain aluminum alloys are recommended for coating with vitreous enamels.

A finely ground enamel composition is mixed with water and applied in a uniform coating by spraying or dipping. The coating is then heated to temperatures of 950-1050 F. High temperatures make necessary the careful support and handling of metal during heating. When warping occurs, subsequent straightening may be necessary. The best enamels for aluminum withstand a reasonable amount of flexing without spalling, therefore, certain operations such as sawing, drilling and punching can be performed on enameled material.

Paint and lacquer finishes can be applied to aluminum, following the same general rules as with other metals. Depending on the application, one of the several proprietary pre-paint finishes discussed above can be applied. Or a conventional paint system may be used. Of the various commercial primer pigments tested for aluminum, zinc chromate appears to have the best corrosion inhibitive properties. Use of lead pigments in priming aluminum should be avoided. For less severe service conditions a variety of primers may be used. In many cases aluminum paint serves well in providing high resistance to moisture penetration, good adhesion and presents sufficient tooth for subsequent coats of paint.

Once a primer is properly applied, almost any durable paint, enamel, lacquer or varnish may be used. For certain applications bituminous paints may be used, though a primer of the same material is recommended.

Acknowledgments

The assistance of literature, and cooperation of personnel of the following organizations is gratefully acknowledged:

Aluminum Association
Aluminum Co. of America
Harvey Aluminum, Div. of Harvey Machine Co., Inc.
Kaiser Aluminum & Chemical Corp.
Reynolds Metals Co.

Reprints of this (and other) Manuals are available at 25¢ each until supply is exhausted. See page 217 for complete list of available Manuals. Write for quotations on quantities of 100 or more. Address requests to Reader Service Dept., MATERIALS & METHODS, 430 Park Ave., New York 22, N. Y.

MATERIALS ENGINEERING FILE FACTS

Steel Heat Treating Temperatures and Hardness after Treatment

AISI Grade	Normalize Temp, F	Rockwell Hardness		Annealing Temp, F	Rockwell Hardness		Quenching		Rockwell Hardness	
							Temp, F	Medium		
1010	1650	B69		1625	B67		1600	water	B77	
1020	1650	B78		1625	B75		1625	water	B95	C16
1030	1600	B85		1600	B82		1550	water		C48
1040	1600	B93		1550	B87		1525	water		C51
								oil	B99	C23
1050	1550	B97		1500	B91		1500	water		C55
1060	1550	B99		1475	B92		1500	water		C56
1080	1550		C25	1450	B95	C16	1475	water		C58
1095	1550		C29	1450	B96	C18	1475	water		C58
2512	1525	B96	C18	1475	B90		1475	oil		C37
2320	1575	B93	C14	1550	B85		1500	oil		C35
2330	1550	B97	C20	1500	B91	C12	1475	water		C53
2340	1550	B98	C21	1500	B93	C14	1475	oil		C58
2345	1525	B100	C24	1475	B94	C15	1450	oil		C58
3120	1600	B93	C14	1575	B85		1550	oil		C36
3130	1575	B96	C18	1500	B91	C12	1500	water		C56
								oil		C46
3135	1575	B96	C18	1500	B93	C14	1500	oil		C56
3145	1575	B99	C23	1475	B94	C15	1475	oil		C60
3240	1600		C29	1500	B96	C18	1475	oil		C60
3245	1600		C30	1500	B96	C18	1475	oil		C60
3312	1500		C20	1500	B95	C16	1475	oil		C43
3330	1500		C25	1475	B97	C20	1450	oil		C53
3340	1550		C29	1475	B98	C21	1450	oil		C55
3435	1550		C25	1450	B95	C16	1425	oil		C51
3450	1525		C29	1450	B96	C18	1425	oil		C56
4030	1600	B96	C18	1550	B87		1525	water		C50
4040	1600	B97	C20	1525	B90		1500	oil		C56
4050	1550		C26	1500	B93	C14	1475	oil		C59
4065	1550		C35	1500	B93	C14	1450	oil		C62
4130	1600	B96	C18	1500	B91	C12	1550	water		C56
								oil		C51
4140	1600		C25	1500	B93	C12	1550	oil		C59
4145	1600		C25	1500	B95	C16	1525	oil		C59
4340	1575		C37	1525	B98	C21	1525	oil		C59
4615	1625	B97	C20	1575	B82		1500	oil		C34
4640	1600	B100	C24	1500	B94	C15	1500	oil		C56
4645	1575	B100	C24	1500	B96	C18	1500	oil		C58
5130	1600	B95	C16	1500	B91	C12	1550	water		C56
5140	1625		C25	1550	B94	C15	1525	oil		C58
5145	1625		C29	1550	B95	C16	1525	oil		C58
5150	1625		C29	1500	B95	C16	1525	oil		C60
6115	1650	B87		1600	B81					
6130	1650	B96	C18	1575	B92	C13	1550	water		C56
6140	1625		C25	1550	B95	C16	1550	oil		C58
6145	1600		C26	1550	B95	C17	1550	oil		C58
6150	1600		C28	1550	B95	C17	1550	oil		C60

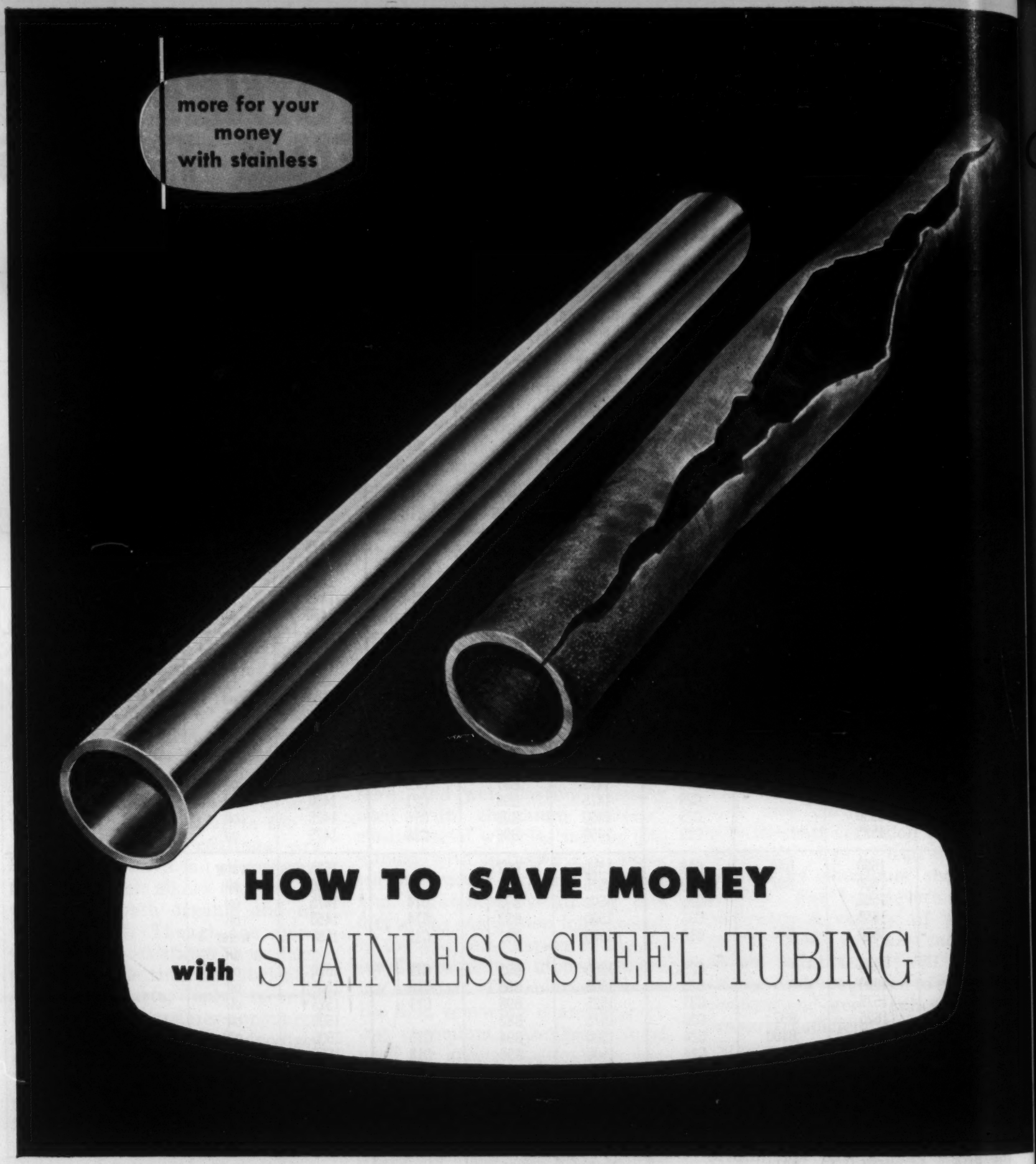
Hardenability Data

Approximate Size of Bars Hardenable to Rockwell C50 at Center

AISI Grade	Water Quench, in.	Oil Quench, in.	AISI Grade	Water Quench, in.	Oil Quench, in.
1050	1	—	3130	1-⅛	9/16
1330	1-¼	11/16	3140	1-⅝	1
1340	1-¼	11/16	A3141	2-½	1-¾
2330	1	½	4150	3-½	2-½
2340	1-⅜	⅞	4340	6	4
5130	1	½	6150	1-⅜	⅞
5145	1-½	⅞	3240	4	3

Courtesy of Swift Industrial Chemical Co.

For more information, Circle No. 468



HOW TO SAVE MONEY

with STAINLESS STEEL TUBING

Downtime and the labor cost of replacing worn-out tubing made of common materials can be a great deal more expensive than the extra first cost of long-lasting stainless.

The tube failure pictured is a dramatic reminder of the indeterminate, and usually shorter, service life of tubing which may bear a smaller price tag, but whose *total* cost can be measured only after the ravages of time and corrosion have tested its durability.

For optimum strength, corrosion resistance and oxidation resistance, there's a stainless grade, size, heat treatment and finish best suited to your particular pressure and temperature requirements. Ask Mr. Tubes, your link to B&W, how to get more for your money with stainless. *Or write for Bulletin TB-356.*

B&W
TUBULAR PRODUCTS DIVISION

THE BABCOCK & WILCOX COMPANY
TUBULAR PRODUCTS DIVISION
Beaver Falls, Pa. and Milwaukee, Wis.: Seamless Tubing, Welded Stainless Steel Tubing
Alliance, Ohio: Welded Carbon Steel Tubing
Milwaukee, Wis.: Seamless Welding Fittings

TA-5038(P)

For more information, turn to Reader Service Card, Circle No. 435

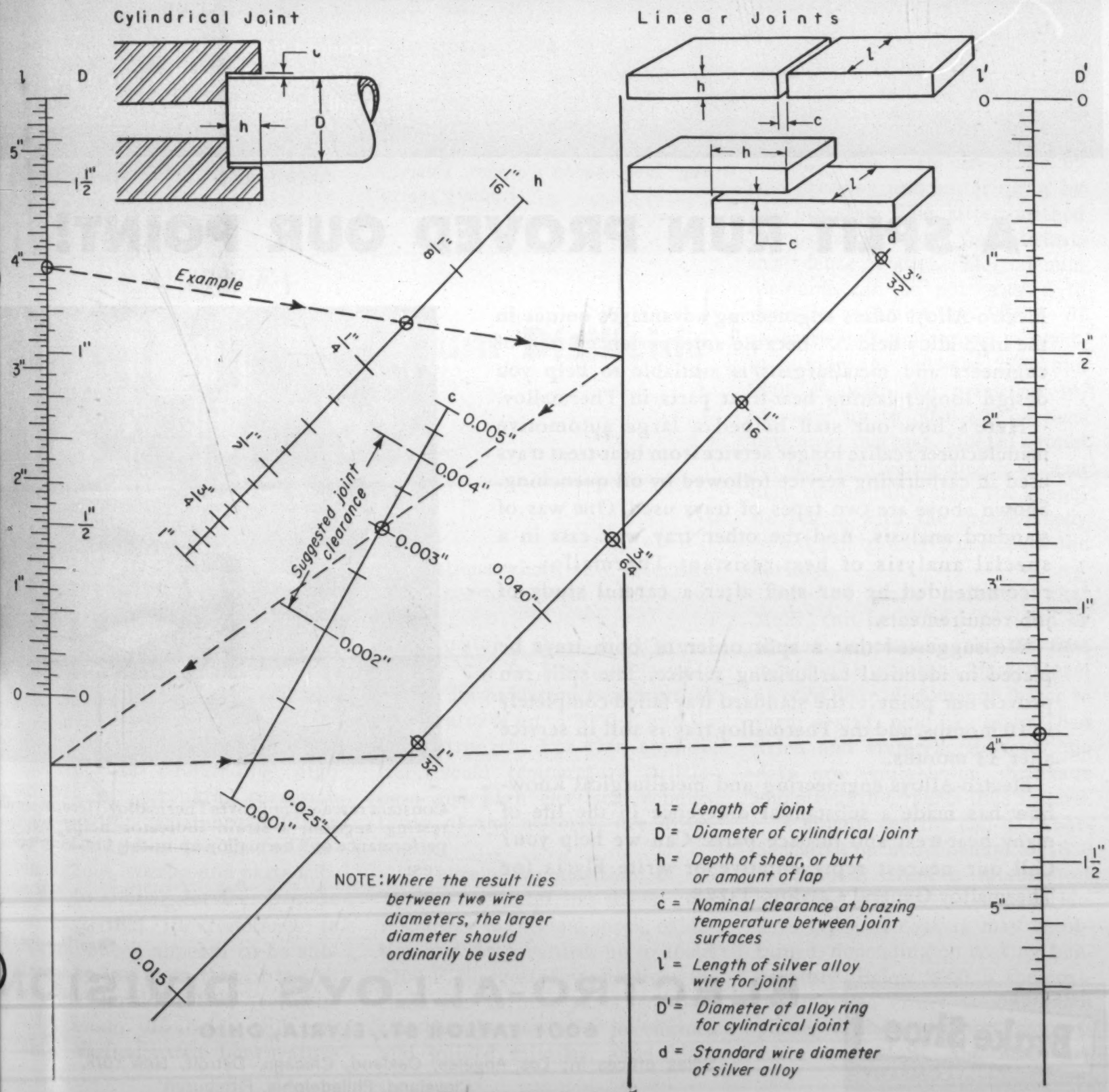
MATERIALS ENGINEERING FILE FACTS

Nomograph Selects Size of Wire for Brazing

This nomograph can be used in two ways. It can indicate the wire diameter needed to silver braze a joint whose diameter (or length), shear depth (or lap), and clearance are known.

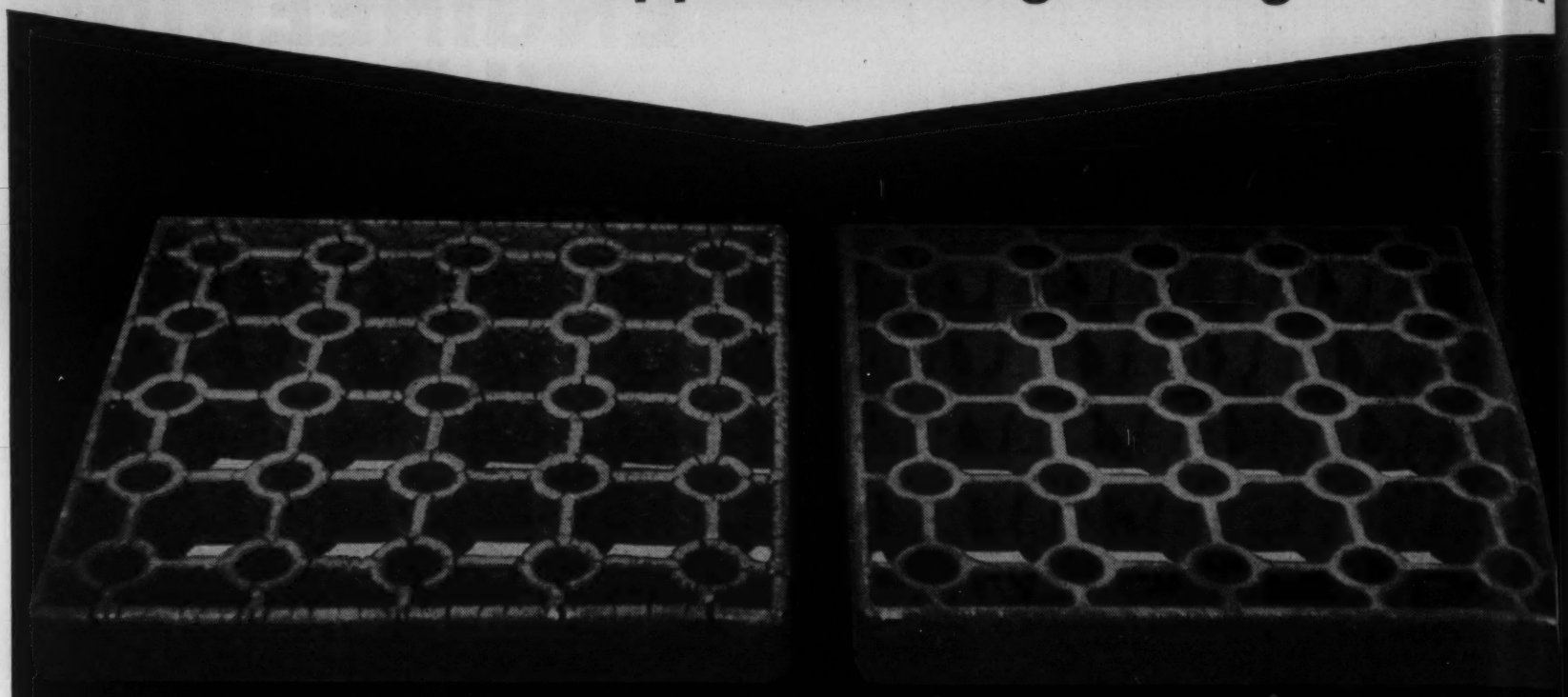
Example: Find proper wire diameter for a silver alloy ring to braze a cylindrical joint having these dimensions: dia 1¼ in.; shear depth, 3/16 in.; and clearance, 0.003 in. Starting on the left, extend a line from joint diameter on the D-scale through shear depth on the h-scale to intersect the center axis. From this point run the line back through the clearance on the c-scale to intersect the left axis. Line up this point with the required ring diameter on D'-scale. The intersection of this line with the d-scale shows wire diameter of 1/32 in. When the result lies between two wire sizes, the larger diameter should normally be selected.

This nomograph can also be used to determine the length of wire needed to make a joint if a given wire gage is already available. Example: To braze a 3-in. linear joint with a ½-in. lap and 0.001-in. clearance with hand fed alloy. Assuming 3/64-in. wire is available, the minimum length of this wire needed per joint can be determined. From the intersecting point on the left-hand axis (found by using the l-, h-, and c-scales), extend a line through the 3/64-in. mark on the d-scale to the l'-scale. The intersection on the l'-scale indicates that for 3/64 wire, a 1⅛-in. length provides the proper volume of silver alloy to fill the joint.



Source: Handy & Harman

THERMALLOY* Application Engineering at Work



Standard trays (left) failed completely in 10 months. Thermalloy tray (right) is still in service after 33 months.

A SPLIT RUN PROVED OUR POINT!

Electro-Alloys offers engineering advantages unique in the high alloy field . . . because an experienced staff of engineers and metallurgists is available to help you design longer lasting heat-treat parts in Thermalloy.

Here's how our staff helped a large automotive manufacturer realize longer service from heat-treat trays used in carburizing service followed by oil quenching. Shown above are two types of trays used. One was of standard analysis. And the other tray was cast in a special analysis of heat-resistant Thermalloy . . . recommended by our staff after a careful study of job requirements.

We suggested that a split order of both trays be placed in identical carburizing service. The split run proved our point . . . the standard tray failed completely in 10 months, and the Thermalloy tray is still in service after 33 months.

Electro-Alloys engineering and metallurgical know-how has made a substantial difference in the life of many heat-treat and furnace parts. Can we help you? Call our nearest representative or write Elyria for Thermalloy General Catalog, T-225.

Constant research improves Thermalloy. Here, in tensile testing section, a strain indicator helps measure performance of Thermalloy up to the breaking point.

*Reg. U. S. Pat. Off.

AMERICAN Brake Shoe COMPANY

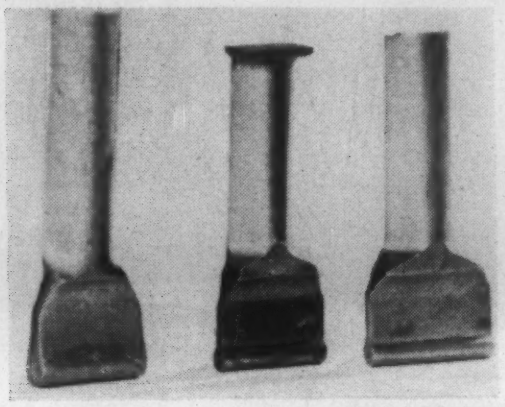
ELECTRO-ALLOYS DIVISION

6001 TAYLOR ST., ELYRIA, OHIO

Sales offices in: Los Angeles, Oakland, Chicago, Detroit, New York, Cleveland, Philadelphia, Pittsburgh

For more information, turn to Reader Service Card, Circle No. 418

NEW MATERIALS PREVIEWS



(*NACA Photos*)

Variety of shapes *can be made from molybdenum disilicide. Top left, slip cast crucibles; bottom left, extruded tubing; above, cast gas turbine blades.*

At 1600 F+

Try Molybdenum Disilicide

for Strength,
Oxidation Resistance,
Corrosion Resistance

Many of the problems of materials engineering encountered in the service temperature range of 1600 to 2000 F and above may be solved by molybdenum disilicide ($MoSi_2$). Though not a brand new material, its engineering characteristics are only now being fully explored. Its outstanding high temperature strength, corrosion and oxidation resistance points to its advantageous use in gas turbine blades, nozzles and parts subjected to similar service. Despite the fact that its resistance to thermal shock appears to be substantially less than that of the titanium carbide-cobalt cermets, molybdenum discilicide will certainly find elevated temperature applications where only moderate resistance to thermal shock is required.

The material shows much promise for use in heating elements due to its oxidation resistance at temperatures up to 3000 F and its good strength. For this application, room temperature brittleness and high electrical conductivity of the material are drawbacks.

A normal composition of 75 $MoSi_2$ –25% Al_2O_3 has shown good resistance to thermal shock, oxidation and temperatures up to about 2700 F. Suggested applications include gas turbine parts, combustion chamber parts for jet engines and guided missiles, sand blast nozzles, kiln furniture, hot draw or hot press dies and induction brazing fixtures.

Vapor deposition of silicon on molybdenum is one means of protecting molybdenum metal from oxidation. The coating consists mainly of an outer layer of $MoSi_2$ and an inner layer of MoSi. The coating is fairly hard but not fragile, and tests show that coated molybdenum filaments have operated at 1800 F for thousands of hours without decomposition. In the form of pure powder, the material is available from *Electro Metallurgical Corp.*, division of Union Carbide and Carbon Corp., 30 East 42nd St., New York 17, and Fansteel Metallurgical Corp., No. Chicago, Ill.

Fabrication

Physical and mechanical properties of molybdenum disilicide bodies depend to some degree on the method of fabrication employed. Most parts are made by cold pressing and sintering or by hot pressing. The latter method is most satisfactory for fabricating dense bodies. Molybdenum disilicide can be hot pressed to densities as high as 98.7% of theoretical. Temperatures currently used range between 2700 and 3000 F, with die pressures increasing up to 5000 psi as temperatures increase. Molded graphite or graphite-clay dies have been used successfully, since the graphite reacts with the pressed body to a depth of only 1 mil below the surface.

Limited work indicates that $MoSi_2$ can be extruded, rolled or molded as ceramic clay if first mixed with a suitable binder, such as corn flour, and enough water to form a stiff, mud-like mass, then dried and sintered. However, no data are available on shrinkage and strength of parts thus formed.

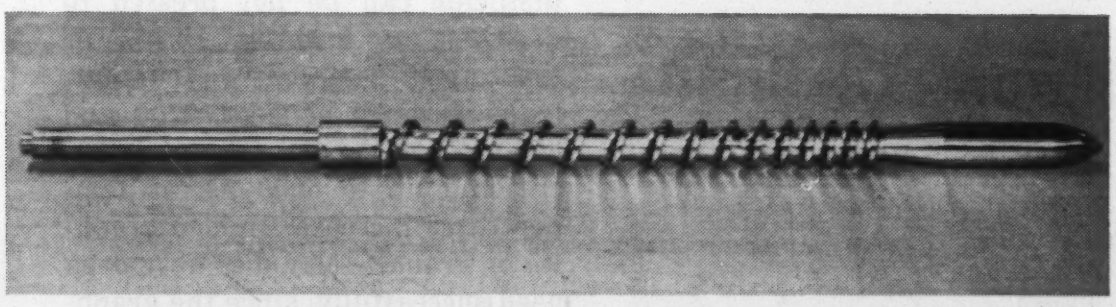
A silicide coating can be vapor-deposited on molybdenum at 1830 to 3300 F from a mixture of hydrogen and silicon tetrachloride. Two types of coating may be obtained, depending on coating temperature. Below 2500 F the coating may be either two or three phase, while at higher temperatures only $MoSi_2$ and MoSi are

Plastiatrics

DOW'S CLINICAL APPROACH TO HEALTHY PLASTICS APPLICATION

PLASTIATRICS HELPS YOU CHOOSE AND USE PLASTICS CORRECTLY

Are you getting the most out of the plastics you need? Do you have the best or the latest for your money? Are you satisfied that plastics are right for the job? That's where *Plastiatrics* comes in . . . to provide a continuous study, analysis and treatment of plastics . . . to understand, prevent or cure plastics problems. Dow, which produces polystyrene under the trade name Styron®, conducts studies in many fields of plastics. For example, continuing studies are undertaken on extrusion. These are of significance to engineers and plastics molders.



DOW'S STUDIES ON IMPROVED SCREW AND TORPEDO DESIGN HELP MAKE POLYSTYRENE EXTRUSION A MORE EXACT SCIENCE

Studies for the development of a better screw and torpedo from polystyrene extrusion are good examples of Plastiatrics at work. Manufacturers using machines equipped with a single flight screw and torpedo arrangement like this one shown here can profitably extrude high-quality polystyrene and get uniformly good results. One thing that was found in working out the details of this better screw was that single flight eliminates blocking in one channel and flowing in another, a problem of the double flight screw that more often than not produces wide variations in product output.

Further studies of the torpedo have led to extensive findings, relative to the use of the torpedo screw, which are available by simply writing Dow.

Standard pressure gage studies another area of Plastiatrics development

Extensive Plastiatrics studies in extrusion have been made on the proper design of dies, take-off equipment and cooling problems. Dow engineers, together with plastics manufacturers, also developed a method for determining optimum pressure and for providing reproducible extrusion performance using a standard gage.

Write for free bulletins

Detailed results of Dow's studies on extrusion are available to you, as they are on all work done in Plastiatrics. For further information, write today . . . Dow Plastics Sales Department PL 456M, THE DOW CHEMICAL COMPANY, Midland, Michigan.

DOW POLYSTYRENE FORMULATIONS:

- Styron® 666 . . . Dow general-purpose polystyrene.
- Styron 688 . . . for controlled flow and controlled pressure distribution in the mold cavity.
- Styron 777 . . . for medium-impact strength.
- Styron 475 . . . for high-impact strength and high elongation.
- Styron 475 sheet . . . for vacuum or pressure forming.
- Styron 480 . . . for extra-high-impact strength.
- Styron 700 . . . for high heat resistance.
- Styron 683 . . . for medium-high heat resistance.

you can depend on DOW PLASTICS DOW

For more information, turn to Reader Service Card, Circle No. 478

obtained, though a layer of molten silicon may be formed with high gas-flow rates or with high concentrations of silicon tetrachloride. Molybdenum disilicide can be cast, though this is complicated by decomposition at the melting point, with loss of appreciable amounts of silicon.

Properties

An accompanying table lists physical and mechanical properties of molybdenum disilicide bodies prepared by both hot pressing and cold pressing and sintering. Specimens have high short-time strength and outstanding oxidation resistance at temperatures of 2000 F and above. The long time strength at high temperatures is superior to that of high temperature alloys and titanium carbide cermets.

No completely satisfactory metallic binder has yet been found. Cobalt, nickel and platinum wet the disilicide, but cannot exist in equilibrium with the material. Further work will have to be done to find metals that will provide a ductile bond. Modulus of rupture of cermets made with molybdenum disilicide and various bonding metals are as follows: hot pressed with cobalt, 60,000 psi; nickel-bonded, 38,600 psi; platinum-bonded, 41,700 psi, and 75 $MoSi_2$ –25% Al_2O_3 about 22,000 to 30,000 psi.

Ductility of the material changes with increasing temperature. At room temperature, $MoSi_2$ behaves in an elastic manner with a brittle failure. At high temperatures, some plastic deformation takes place. At red heat, for example, siliconized molybdenum wire can be wound into tight coils without damage to the coating.

The outstanding resistance of molybdenum disilicide to corrosion and oxidation is attributed to formation of a protective coating of silica. $MoSi_2$ is unattacked by most inorganic acids, though it is attacked rapidly by mixtures of hydrofluoric and nitric acids. It is not attacked by aqueous solutions of alkalies, but is easily soluble in molten alkalies. It is resistant to molten metals in varying degrees. It has good-to-excellent resistance to liquid sodium. Hot pressed specimens are wetted by bismuth, but show no visible corrosion after a week's immersion at 2500 F. Hot pressed bars submerged in tin are pitted after a week at 1800 F. Siliconized molybdenum has excellent resistance to molten zinc at 800 F and is resistant to attack by gallium as long as the coating is not cracked.

Fluorine attacks molybdenum disilicide at room temperature, and chlorine at elevated temperatures. It is not markedly affected by a bromine-hydrogen stream even at red heat. Life of siliconized molybdenum in air depends on the coating thickness, as failure is apparently due to diffusion of silicon from the outer layer into the interior.

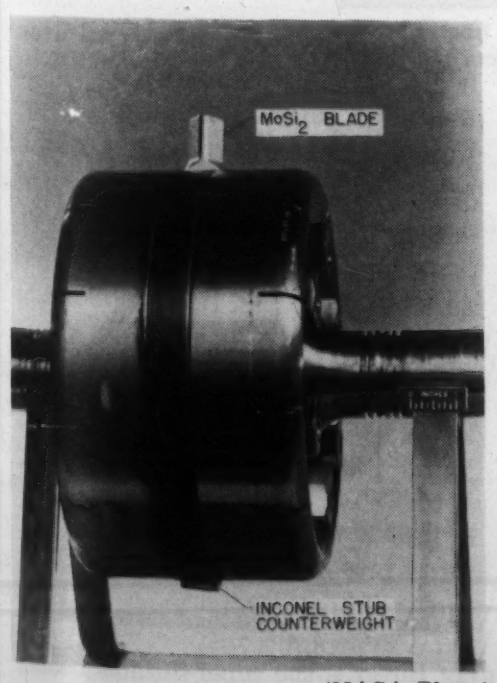
Thermal shock

Poor thermal shock resistance is the major deficiency of molybdenum disilicide. Additional developmental work seems to be necessary before the materials can be used in gas turbine blades. A series of tests on various ceramic and cermet materials showed that a 75 $MoSi_2$ –25% Al_2O_3 cermet was superior to pure molybdenum disilicide, though it was inferior to TiC-Co, in this respect.

Acknowledgments

Information compiled by Climax Molybdenum Co. from literature.

(*More New Materials Previews on p.* 135)



(NACA Photo)

Testing molybdenum disilicide *in a rotor assembly under simulated service conditions.*

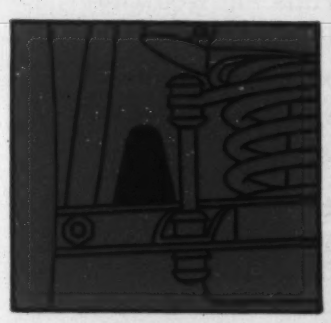
TYPICAL PROPERTIES OF MOLYBDENUM DISILICIDE

Density, g/cc	about 6	
Hardness		
Cold pressed and sintered, Rc	57	
Hot pressed, Ra	80–87	
Tensile Strength, short time, psi		
1800 F	40,000	
2200 F	42,800	
2400 F	41,000	
Compressive strength, psi	350,000	
Short time modulus of rupture (carbon added), psi	Pressed & Sintered	Hot Pressed
1800 F	67,250	—
2000 F	86,250	72,000
2200 F	[1]	55,000
Stress rupture strength, 100 hr, psi		
1800 F	30,000	
1900 F	13,500	
2000 F	8500	
Coef of lin therm exp, (at 80-2700 F), in./in.	5.1×10^{-6}	
Corrosion in air, (at 100-2850 F), g/sq cm-hr-max	3.1×10^{-6}	

[1] *Test not applicable because bars showed too much plasticity.*

In over 100 places, **Enjay Butyl rubber parts**

add to Pontiac performance



Axle bumper

Body seals, gaskets, insulators, pads, grommets, etc.

Brake and accelerator pedal pads, bellows

Radiator and heater hoses, ducts

Gearshift lever cover

Pontiac has been using parts made of Enjay Butyl since 1946. The great '56 model now incorporates more than 100 parts made from this super-durable rubber, adding to its performance, style and value. These parts have amazing resistance to deterioration and will easily last the life of the car.

Among the many advantages of Enjay Butyl are *price* and *ready availability*. And it is now available in non-staining grades for white and light-colored parts. Extensive laboratory and testing facilities are at your service. For the full story, contact the Enjay Company today.

ENJAY BUTYL

Enjay Butyl is the super-durable rubber with *outstanding* resistance to aging • abrasion • tear • chipping • cracking • ozone and corona • chemicals • gases • heat • cold • sunlight • moisture

ENJAY **ENJAY COMPANY, INC., 15 West 51st Street, New York 19, N. Y.**
District Office: 11 South Portage Path, Akron 3, Ohio

36 SUCCESSFUL YEARS OF LEADERSHIP IN SERVING INDUSTRY

For more information, turn to Reader Service Card, Circle No. 437

NEW MATERIALS PREVIEWS

Epoxy Resin Systems

- *One component casting resin*
- *Paste laminating resin*
- *Strain gage sealing compound*
- *Low viscosity resin*
- *New curing agent*

One component casting resin

A series of single-component casting resins requiring no catalysts or hardeners has been developed by *Aries Laboratories, Inc.*, 270 Park Ave., New York 17. Called Aritemp, the resins are free-flowing powders which, on melting, form low viscosity solutions permitting impregnation and sealing of complex electronic components. Use of the materials is said to simplify production and eliminate possibility of errors in formulation. According to Aries, the cured resins become rubbery rather than brittle at high temperatures, thus enabling their use with small wires and fragile components. Potted components may be cycled from —75 to 302 F without developing cracks or dielectric losses.

Paste laminating resin

Called Epocast 2 C, a new paste laminating resin, said to have thixotropic characteristics which permit it to cling on vertical walls and ceilings without sagging, has been developed by *Furane Plastics, Inc.*, 4516 Brazil St., Los Angeles 39. In applying, a hardener is mixed with the resin and the formulation is brushed on surfaces to be protected. Glass cloth is then pressed into place and squeegeed or rolled down. Though the resin is a paste, it is said to penetrate and wet the glass cloth rapidly and thoroughly. The material is recommended for preparing corrosion resistant surfaces on industrial structures; laminating glass reinforced jigs and fixtures, and in surfacing wood, metal and concrete storage tanks.

Waterproof strain gage sealer

A resilient, waterproof epoxy compound has been developed for sealing strain gages, by the *Epoxylite Corp.*, 812 Truck Way, Montebello, Calif. Called Epoxylite #222, the material is said to be unaffected by water immersion; will not damage the strain gage since it contains no solvents; and requires no heating of either the gage or test hardware. It will withstand a maximum service temperature of 300 F. During solvent resistance tests extending for a month, the material showed no swelling in contact with SR-10 aviation fuel and only 5% swell with either JP-3 jet fuel or SR-6 aromatic aviation gas.

Low viscosity resin

A low viscosity (500-900 cps) structural resin which penetrates closely woven glass cloth rapidly has been marketed by *Shell Chemical Corp.*, 50 W. 50th St., New York 20. Called Epon 815, the 100% reactive resin is said to be particularly useful in laminates prepared by vacuum-bag and contact-pressure techniques. Resulting laminates have higher glass content than laminates prepared with other resins, and hence, greater strength. Contact pressure laminates can be prepared with glass contents as high as 60%, while vacuum-bag laminates can contain up to 70% glass. The resin can also be used in castings or as an adhesive. Castings can incorporate more filler than usual, permitting better control of exothermic heat and shrinkage. According to Shell, the resin should be particularly useful in the plastics tooling industry, where ease of handling and low viscosity are advantageous.

Room temperature curing agent

Shell has also developed a new curing agent for epoxies, Epon Curing Agent T, designed to reduce handling problems associated with use of the aliphatic polyamine hardeners. A low viscosity, high boiling liquid, the hardener is expected to find use in room temperature contact-pressure laminating, especially in the plastics tooling field and in auto body patching kits. Its low viscosity results in better wetting of glass cloth. Optimum rate of cure reults from use of a concentration of 25% of the agent, based on weight of resin used. At this concentration a wet lay-up contact pressure laminate becomes tack-free in about 4 hr at room temperature. With infrared heating, adequate cures are obtainable in 5 to 10 min.

Coating and Finishing Materials

Several recently developed coating and finishing materials include: 1) a zinc pigmented protective coating; 2) a fast drying enamel for large equipment; 3) a new multi-colored lacquer; 4) a strippable coating for paint areas; and 5) a silicone additive that provides paints with a hammer finish.

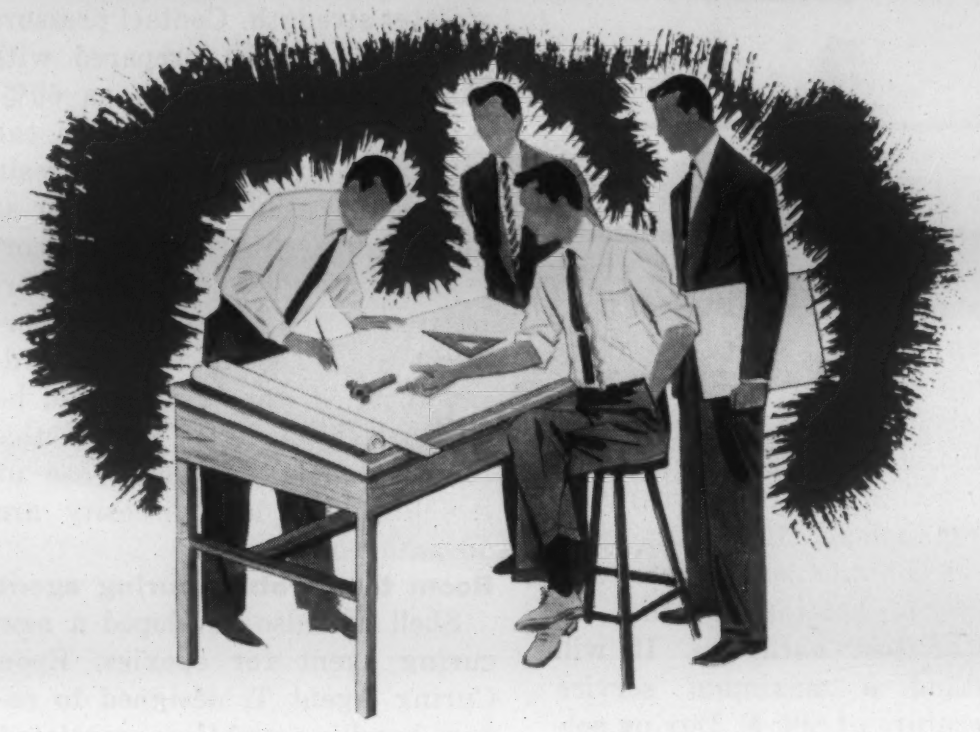
Zinc coating

A coating, consisting of 95% pure zinc has been marketed by *Wilbur & Williams Co.*, Boston 35, Mass. It can be applied with brush or spray gun to renew galvanizing on parts that have lost original protective coatings or to provide zinc protection to standing towers, fences, air conditioning ducts, etc.

Fast drying enamel

A line of fast drying synthetic finishes for manufacturers of heavy equipment such as farm and road machinery and machine tools is being marketed by *E. I. du Pont de Nemours & Co.*, Wilmington, Del. Called 113-Line Fast Drying Finishes, the pigmented enamels in most colors can be handled in about 15 min after application. Reds and blacks may require about 30 min. They dry tack-free in two or three hours. The coatings are said to have a

THIS IS FOR MEN...



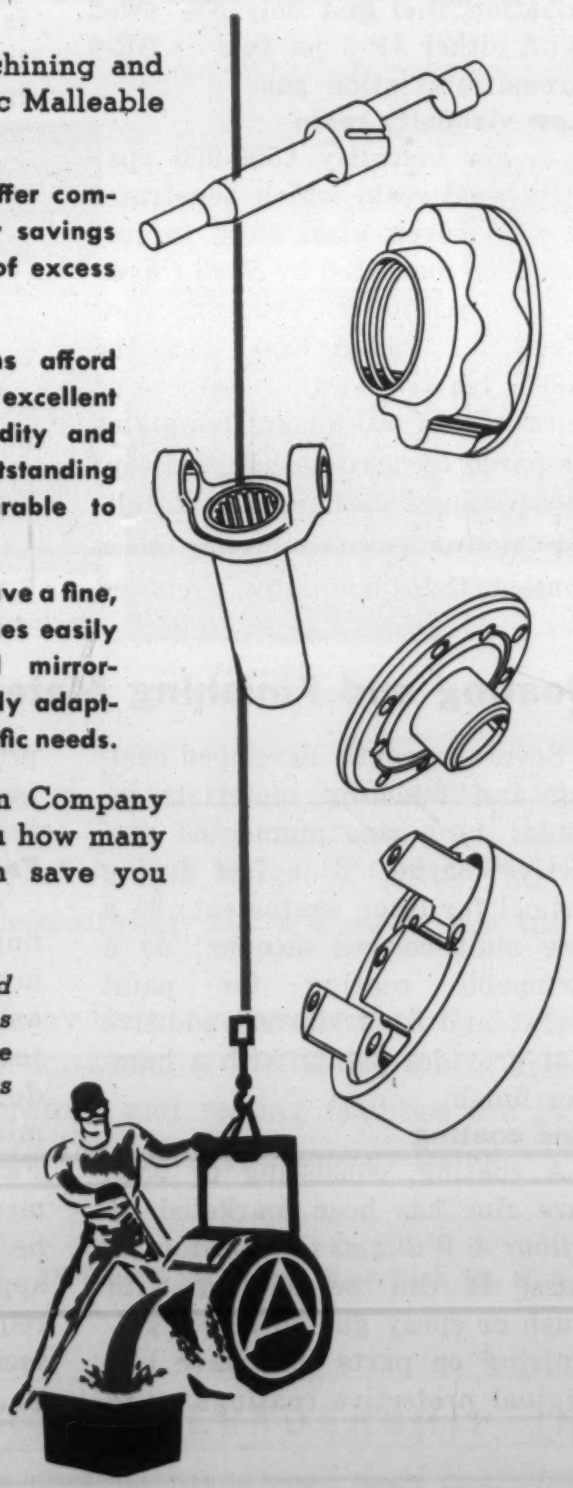
. . . who are interested in the advantages of of PEARLITIC MALLEABLE CASTINGS

● You can slash production, machining and assembly costs with Albion Pearlitic Malleable Iron Castings. And, here's why:—

. . . Albion's pearlitic malleable irons offer complete freedom of design for greater savings in machining time, the elimination of excess metal and lower finished part cost.

. . . Albion's pearlitic malleable irons afford unusually fine wear resistance with excellent bearing properties. Maximum rigidity and prolonged fatigue life offers outstanding endurance. Yield strength comparable to steel forgings.

. . . Albion's pearlitic malleable irons have a fine, uniform grain structure that machines easily and accurately with exceptional mirror-smooth finishing qualities. Extremely adaptable to localized hardening for specific needs.



Contact the Albion Malleable Iron Company now . . . they'll be glad to show you how many ways Albion's pearlitic irons can save you time, tools and dollars.

Remember . . . Albion's Research and Development Laboratory facilities and competent engineering staff are ready to help you design better products that can be made at lower cost.

ALBION MALLEABLE IRON CO.

Albion, Michigan

For more information, turn to Reader Service Card, Circle No. 472

NEW MATERIALS PREVIEWS

high degree of adhesion when applied directly to solvent cleaned metal. They have good resistance to gasoline, oil and water, and good flexibility and durability.

Multi-colored lacquer

A new coarse pattern for the multi-colored lacquer Zolatone has been developed by *Paramount Paint & Lacquer Co.*, 3411 E. 15th St., Los Angeles 36. Zolatone Tadpoles can be added to any multi-color combination, which in turn can be sprayed onto any properly prepared surface, creating a decorative effect in a single operation. The material is non-static, scrubbable and effectively hides flaws.

Strippable coating

A strippable coating which can be sprayed on paint spray booths and other spray areas and easily stripped off when over-spray accumulates has been marketed by *Guard Coatings Corp.*, 8-05 43 Ave., Long Island City, N. Y. Called BoothGuard, the water-type coating is nonflammable in liquid form and will cover with one coat. According to the manufacturer, the coating will not feather or web when sprayed on, nor tear or shred when stripped off. On drying, the material forms a thin white film.

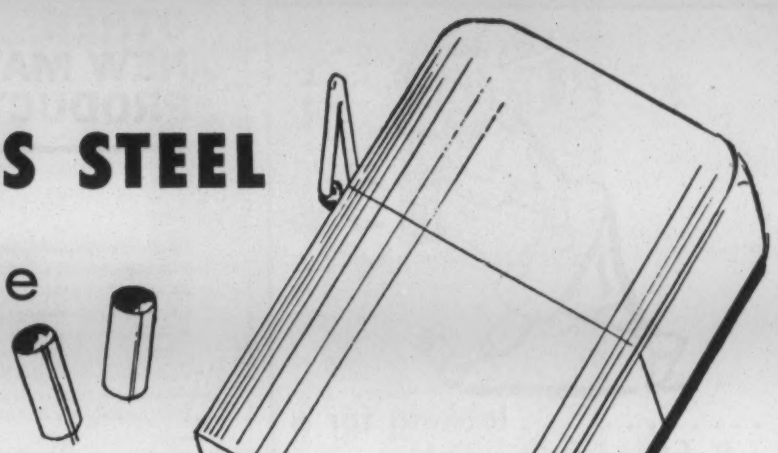
Silicone additive provides hammer finish

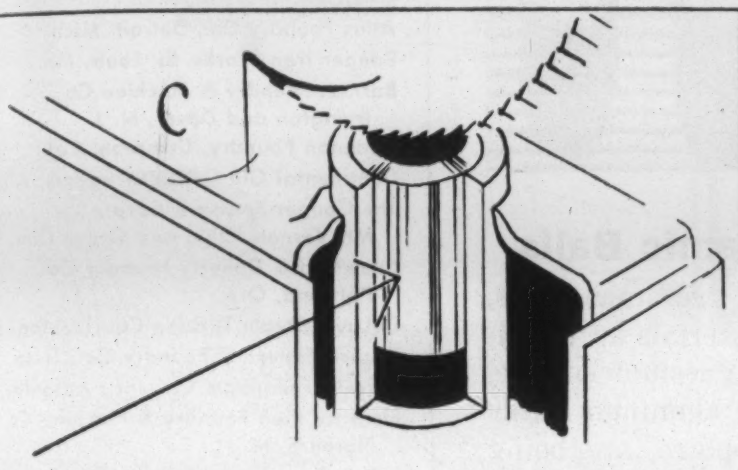
A silicone additive which provides metallic paints with a hammer finish has been marketed by *Dow Corning Corp.*, Midland, Mich. Identified as F-4290, it is said to be effective in concentrations as low as 0.1 to 1.0% by weight. Varying the concentration produces a variety of hammer effects, ranging from coarse to fine. The material adds from three to five cents per gallon to the cost of the paint. A solution of silicone polymer in xylene, F-4290 is ready to use and can be mixed with drying type alkyds; epoxies; soya alkyd-melamine; coconut alkyd-melamine; silicones and modified silicones; and acrylic, nitrocellulose or ethyl cellulose lacquers.

(Other New Materials on p. 138)

HOW ARMCO 17-7 PH STAINLESS STEEL keeps this lighter in shape

A tiny hardened Armco 17-7 PH Stainless Steel bushing is the key to dependability and long service life of a well-known lighter.





WHAT THE STAINLESS BUSHING DOES

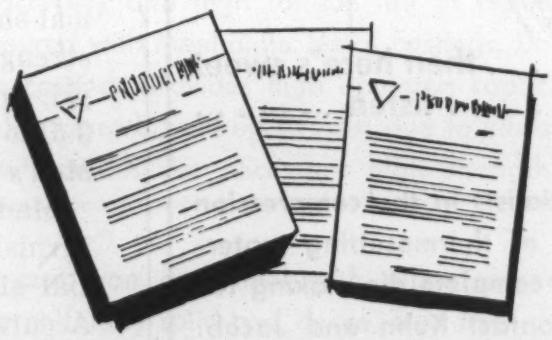
This collar in the top of the tube keeps the flint in alignment and prevents jamming. The collar must be perfectly formed and very hard. That's why it's made of Armco 17-7 PH Stainless Steel, precipitation hardened.

NO "FLOPOVER" FLINTS

In an ordinary flint tube, repeated pressure of the spark wheel against the flint causes the end of the tube to expand. This permits the flint to "flop over," making the lighter useless.

WHAT THIS STEEL OFFERS YOU

Consider the advantages of Armco 17-7 PH Stainless Steel for your products. It can be drawn and formed in the annealed condition to close tolerances. Then, it can be hardened at low temperatures to tensile strengths of around 200,000 psi. It is "transformed" by holding at 1400 F for 1½ hours and cooling to 60 F or below. Hardening is completed by heating to 950-1050 F, holding for ½ to 1½ hours and cooling.



GET COMPLETE DATA

Armco 17-7 PH is produced in sheets, strip, plates, bars and wire. Besides, there is a single heat treatment precipitation-hardening stainless steel, Armco 17-4 PH, made in bars, wire and billets only. For complete information on these special Armco Stainless Steels, just fill out the coupon and mail it to us.

ARMCO STEEL CORPORATION
1585 CURTIS STREET, MIDDLETOWN, OHIO

SPECIAL STEELS

Sheffield Steel Division • Armco Drainage & Metal Products, Inc. • The Armco International Corporation

ARMCO STEEL CORPORATION, 1585 Curtis Street, Middletown, Ohio

Send me information on Armco Precipitation-Hardening Stainless Steels.

Name:_____

Firm:_____

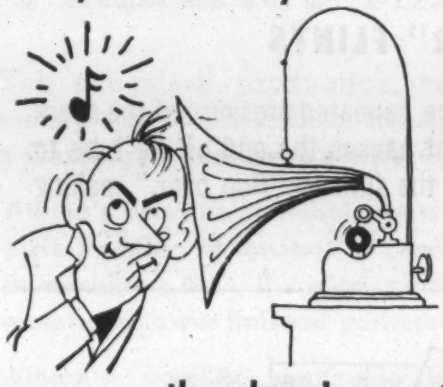
Street:_____

City:_____ Zone:_____ State:_____

For more information, turn to Reader Service Card, Circle No. 421

. . . . . looking for a reliable plastic molder . . . . .

. . . . . who knows you're his bread and butter and . . . . . treats you that way . . . . . .



. . . . . then here's sweet music . . . . . listen . . . . . .

For specialists in the compression molding of thermosetting materials and complete die making facilities contact Kuhn and Jacob. Let their sales and engineering staff save you money on your present jobs and future needs.

Write for Free Catalog

KUHN & JACOB MOLDING & TOOL CO.

1203 Southard St., Trenton 8, N.J.

Represented by

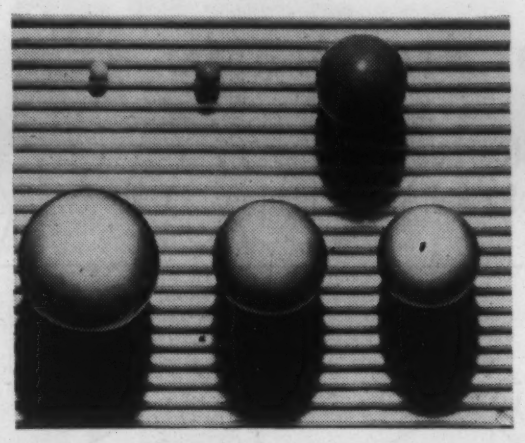
S. C. Ullman
55 West 42nd St., New York, N. Y.
Phone PEnn 6-0346

Wm. A. Chalverus
Carson Road, Princeton, N. J.
Phone 1-3170-J2

Wm. T. Wyler
Box 126, Stratford, Conn.
Phone Bridgeport 7-4293

For more information, Circle No. 454

OTHER NEW MATERIALS, PRODUCTS



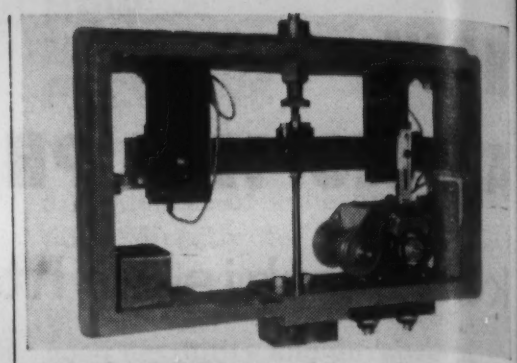
Precise Ceramic Balls

High-precision ceramic balls, made of such materials as aluminum silicate, magnesium silicate, titanium dioxide, aluminum oxide and sintered sapphire, are being produced by *Industrial Tectonics, Inc.*, Ann Arbor, Mich. Properties differ depending on the material selected. However, generally, the balls have high resistance to corrosion, abrasion and high temperatures, high dielectric strength, zero water absorption, low thermal conductivity and good thermal shock resistance. Compressive strength is usually over 300,000 psi, specific gravity ranges from 3.5 to 4.0 and hardness is 9 on Moh's scale.

Made to order, the balls can be furnished in any standard or special size from ¼ to 4½ in. dia. Accuracy is held to ±0.0002 on diameter and ±0.00005 in. on sphericity in the smaller sizes, and to ±0.0005 in. on diameter and ±0.0002 in. on sphericity on 4½ in. balls.

Free-Machining High Strength Steel

A new free-machining steel bar with a tensile strength, unheat-treated, in the range of 140,000 to 150,000 psi and a hardness of about Rc30 has been developed by *La Salle Steel Co.*, Hammond, Ind. Called Fatigue-Proof, the bar is said to be suitable for replacing several heat treated, hot rolled or cold finished steels in various carbon or alloy grades. Eliminating



MEEHANITE CASTINGS ARE MADE ONLY BY MEEHANITE FOUNDRIES

The American Laundry Machinery Co., Rochester, N. Y.
Atlas Foundry Co., Detroit, Mich.
Banner Iron Works, St. Louis, Mo.
Barnett Foundry & Machine Co., Irvington and Dover, N. J.
Compton Foundry, Compton, Calif.
Continental Gin Co., Birmingham, Ala.
The Cooper-Bessemer Corp., Mt. Vernon, Ohio and Grove City, Pa.
Crawford & Doherty Foundry Co., Portland, Ore.
DeLaval Steam Turbine Co., Trenton, N. J.
Empire Pattern & Foundry Co., Tulsa, Okla.
Farrel-Birmingham Co., Inc., Ansonia, Conn.
Florence Pipe Foundry & Machine Co., Florence, N. J.
Fulton Foundry & Machine Co., Inc., Cleveland, Ohio
General Foundry & Mfg. Co., Flint, Mich.
Georgia Iron Works, Augusta, Ga.
Greenlee Foundry Co., Chicago, Ill.
The Hamilton Foundry & Machine Co., Hamilton, Ohio
Hardinge Company, Inc., New York, N. Y.
Hardinge Manufacturing Co., York, Pa.
Johnstone Foundries, Inc., Grove City, Pa.
Koehring Co., Milwaukee, Wis.
Lincoln Foundry Corp., Los Angeles, Calif.
Palmyra Foundry Co., Inc., Palmyra, N. J.
The Henry Perkins Co., Bridgewater, Mass.
Pohlman Foundry Co., Inc., Buffalo, N. Y.
Rosedale Foundry & Machine Co., Pittsburgh, Pa.
Ross-Meehan Foundries, Chattanooga, Tenn.
Shenango-Penn Mold Co., Dover, Ohio
Sonith Industries, Inc., Indianapolis, Ind.
Standard Foundry Co., Worcester, Mass.
The Sterns-Roger Mfg. Co., Denver, Colo.
Valley Iron Works, Inc., St. Paul, Minn.
Vulcan Foundry Co., Oakland, Calif.
Washington Iron Works, Seattle, Wash.
Hartley Foundry Div., London Concrete Machinery Co., Ltd., Brantford, Ontario
E. Long Ltd., Orillia, Ontario
Otis Elevator Co., Ltd., Hamilton, Ontario

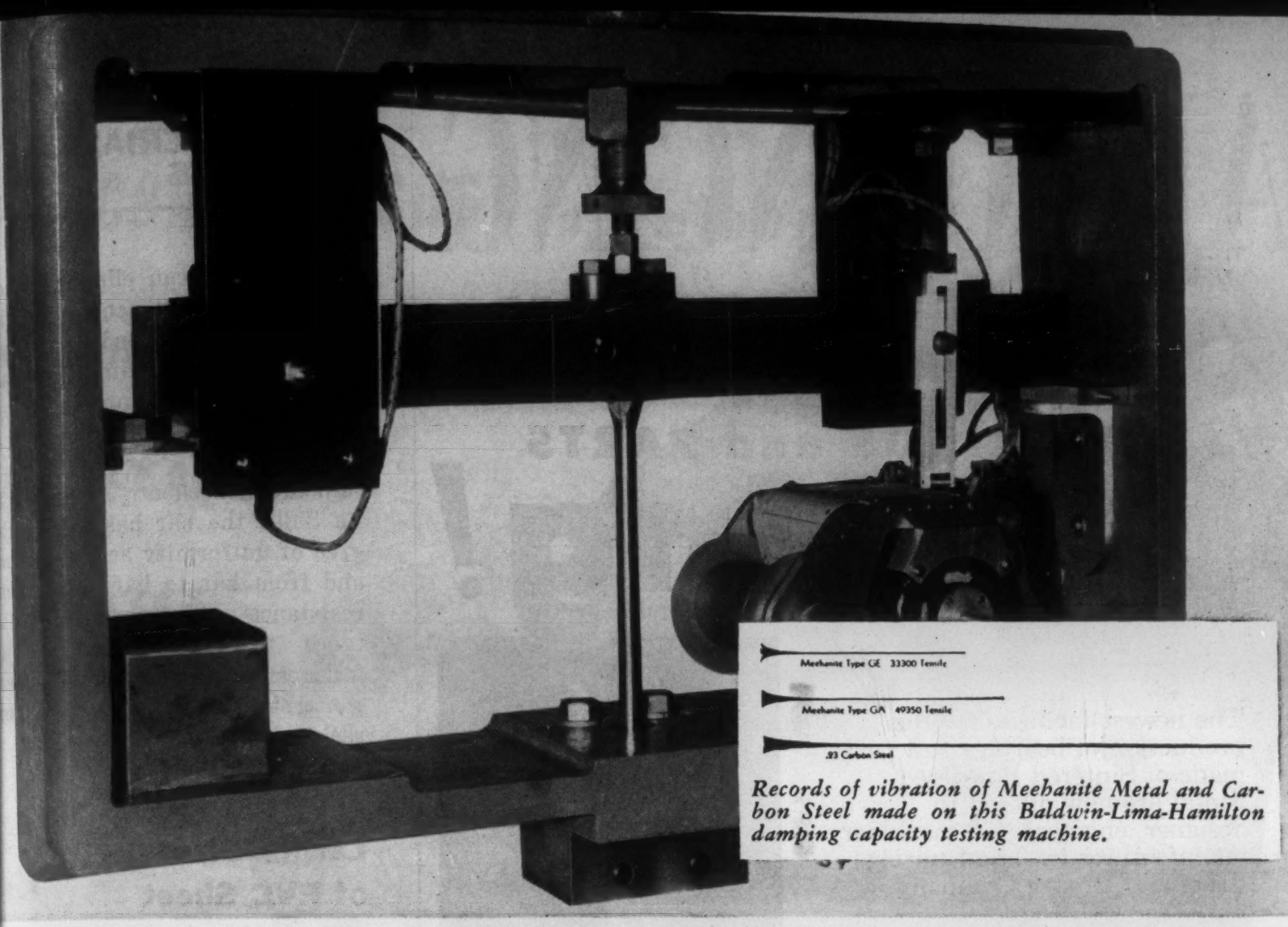
SEND FOR THESE BULLETINS TODAY

- **HANDBOOK OF MEEHANITE METALS**
- **MEEHANITE METAL AS A GEAR MATERIAL**
- **MEEHANITE CAMS, CAMSHAFTS, AND CRANKSHAFTS**

Write today to Meehanite Metal Corporation, Dept. 3C, 714 North Avenue, New Rochelle, N. Y.

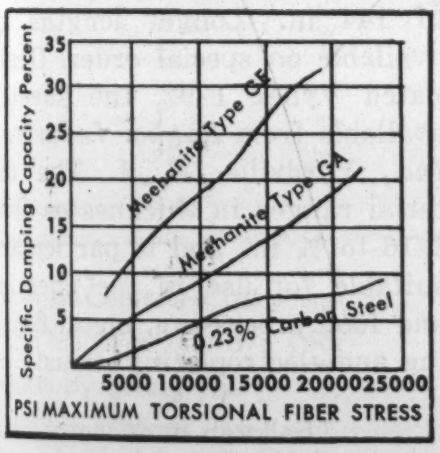
MEEHANITE®

For more information, Circle No. 481



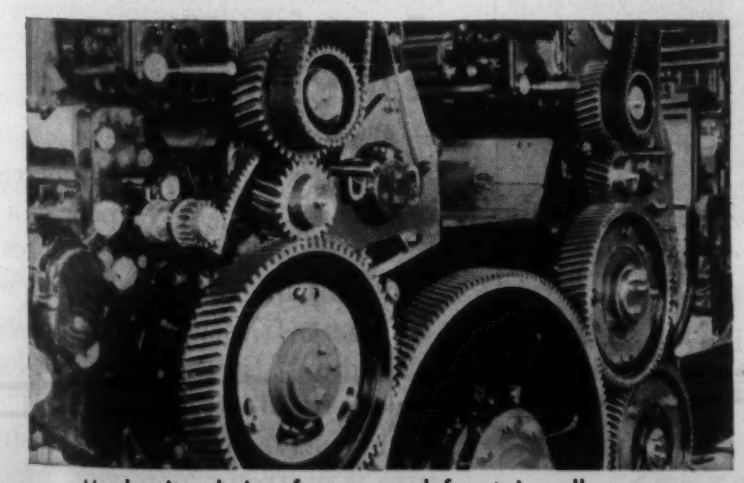
Records of vibration of Meehanite Metal and Carbon Steel made on this Baldwin-Lima-Hamilton damping capacity testing machine.

MEEHANITE CASTINGS POSSESS SUPERIOR VIBRATION DAMPING PROPERTIES AT HIGH STRESS RANGES

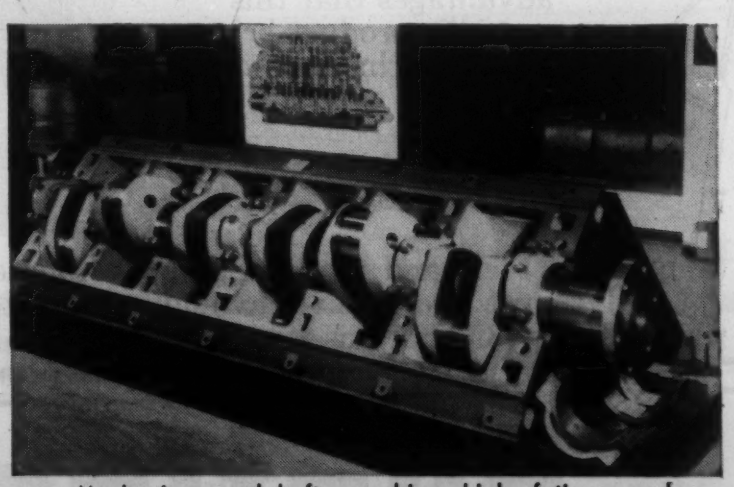


Extreme accuracy in precision machinery and high fatigue life of repeatedly stressed machined parts can be assured with Meehanite Metal castings. Uniform graphite distribution in Meehanite castings provides high damping capacity — 3 times that of steel — (see graph) to absorb built-up stresses due to vibrations. A wholly pearlitic base structure provides the necessary high strength and wear resistance.

Combining the best features of cast iron and steel with other engineered properties, Meehanite castings are uniformly solid and dense, free from defects and readily machinable. *For additional information write to Meehanite Metal Corporation, New Rochelle, New York.*



Meehanite chain of gears and fountain rolls assure perfect register and minimum friction and noise in high speed printing operations.



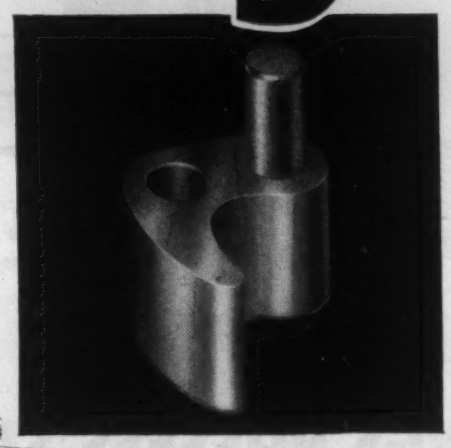
Meehanite crankshafts combine high fatigue and wear resisting properties with excellent damping qualities that reduce resonant vibrations and provide smoother engine performance.

MEEHANITE METAL®

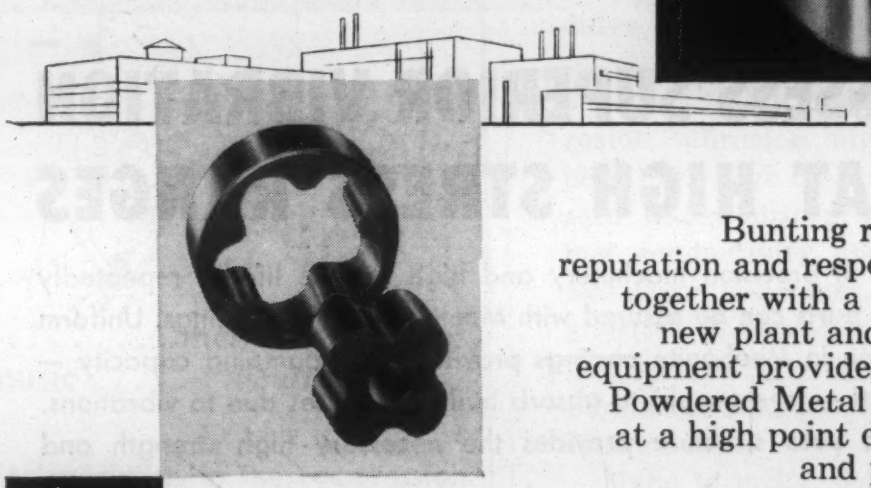
MEEHANITE METAL CORPORATION • NEW ROCHELLE • NEW YORK

ANNOUNCING

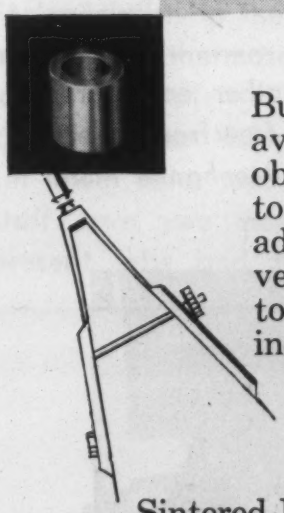
...SINTERED POWDERED METAL BEARINGS and PARTS by Bunting!®



The newest facilities for the production of bearings and parts made of Sintered Powdered Metal are now offered to designer, engineer and machinery manufacturer by The Bunting Brass and Bronze Company.



Bunting resources, reputation and responsibility together with a complete new plant and modern equipment provide Sintered Powdered Metal products at a high point of quality and precision.



Bunting Engineering is available without cost or obligation to all who wish to use or explore the cost advantages that this versatile product brings to the mechanical industries.

Sintered Plain and Flange Bearings, Solid and Tubular Bars and Thrust Bearings are available from stock in a wide range of sizes. Quotations for special bearings or special parts will be sent promptly on receipt of prints.

Bunting®

BUSHINGS, BEARINGS, BARS AND SPECIAL PARTS OF CAST BRONZE AND POWDERED METAL

The Bunting Brass and Bronze Company • Toledo 1, Ohio • Branches in Principal Cities

For more information, turn to Reader Service Card, Circle No. 403

OTHER NEW MATERIALS, PRODUCTS

heat treating can eliminate such costly items as quench cracks, distortions, cleaning, and straightening. The bar machines at least 25% faster than annealed alloys and 50 to 100% faster than heat treated alloys. Surface finish is said to be excellent. According to La Salle, the bar has a high degree of uniformity across the bar and from bar to bar; high wear resistance and increased resistance to fatigue and service failures; a high degree of dimensional stability; and freedom from residual stresses.

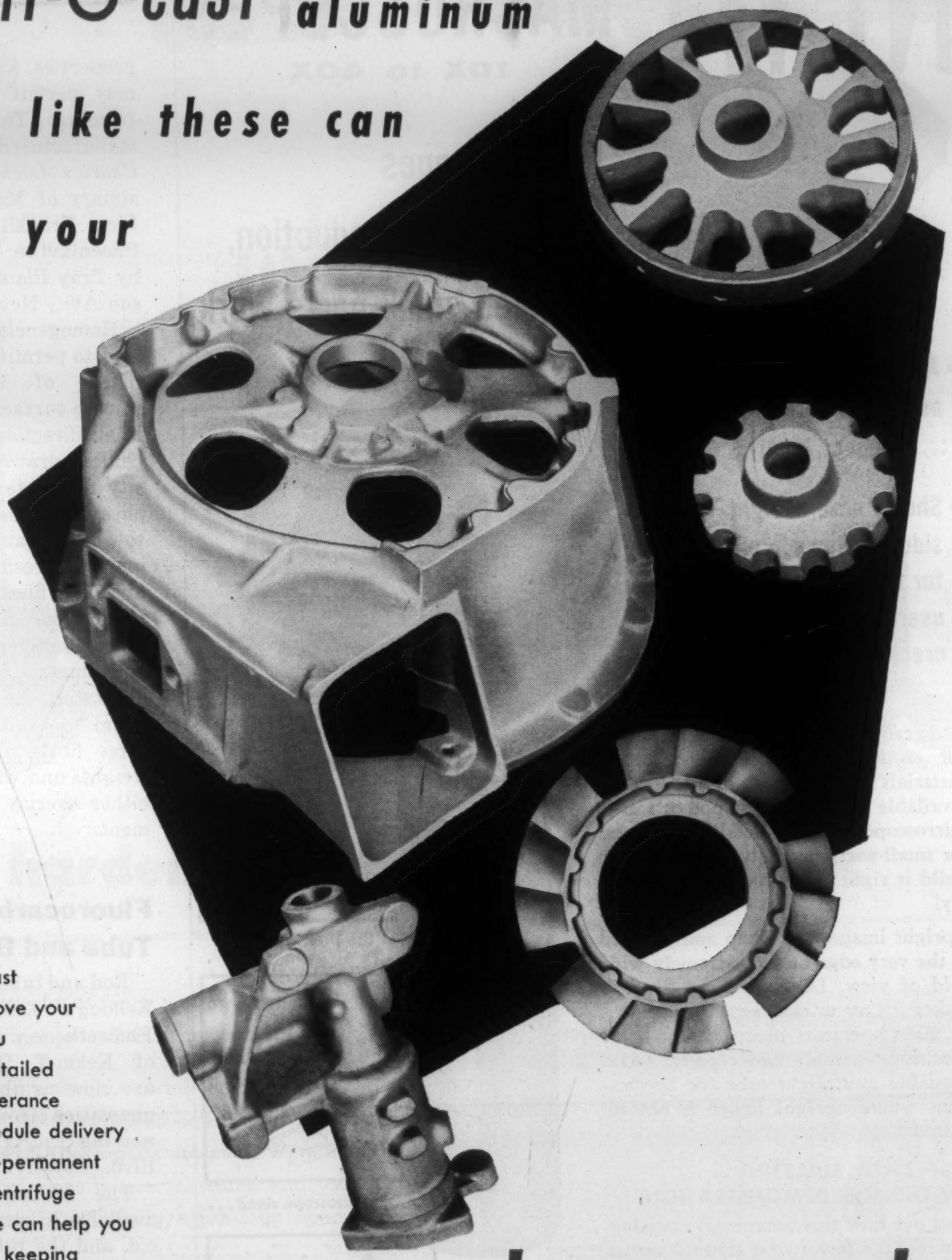
Larger Sizes of PVC Sheet

Unplasticized polyvinyl chloride plastics for use as corrosion-resistant linings or as structural materials is now available in sheets 44 in. wide by any length desired to a standard maximum of 144 in. Longer lengths are available on special order. Designated Vyflex F-92, the sheet is available from *Kaykor Industries, Inc.*, Yardville, N. J. The material ranges in thicknesses from 1/16 to 3/8 in., and is particularly suitable for use in the chemical and food processing, metal finishing and electroplating industries.

Synthetic Fiber Mat Reinforces Plastics

A mechanically bonded laminate material made of nylon, dacron or orlon has been developed as a reinforcing material for plastics by two companies in cooperation with Du Pont. It is made by passing a carded batt through a needle loom, which, in effect, stitches the fibers to themselves. The resultant structure is a strong, non-woven fabric which can be readily molded or tailored. Preliminary reports from plastics molders indicate the reinforcing material may provide reinforced plastics parts with better abrasion resistance, electrical

let us show you how centr-O-cast aluminum castings like these can improve your products



Here at Centr-O-Cast we can help you improve your products by giving you careful attention to detailed requirements, close-tolerance uniformity and on-schedule delivery on permanent or semi-permanent mold, centrifugal or centrifuge aluminum castings. We can help you quality-wise while still keeping unit costs in line.

Working in all the aluminum alloys, either regular or heat-treated, we are equipped to produce for you castings ranging from 2 ounces to 65 pounds.

Write and tell us your casting problem. A card will bring an illustrated brochure, or, if you prefer, a personal call by our casting consultant.

centr-O-cast

CENTR-O-CAST AND ENGINEERING COMPANY

45 St. Jean Avenue, Detroit, Michigan

51

For more information, turn to Reader Service Card, Circle No. 401

NEW!

BAUSCH & LOMB WIDE FIELD MACROSCOPES

10X to 40X

Handy 'scopes spot-check production, speed small parts work

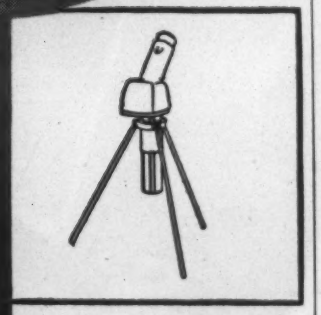
- Actual size as shown here ... compact, handy
- Shows natural right-side-up views... easier for inexperienced users... a big help in precision assembly!

Just grab this dependable inspection aid for on-the-spot checks of work and materials in any phase of production. Available with folding tripod or sturdy microscope stand, for detailed study and for small-parts assembly. You can even build it right into production machinery!

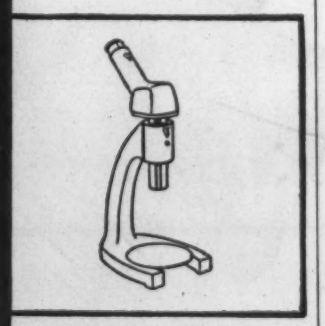
Upright images are sharp and detailed to the very edge of the extremely wide field of view. Long working distance makes it easy to manipulate specimens ... gives operators plenty of room for precision assembly and repairs. (Also available as straight tube for applications where upright image is not required.)

FREE DATA BULLETIN!
ON-THE-JOB DEMONSTRATION!

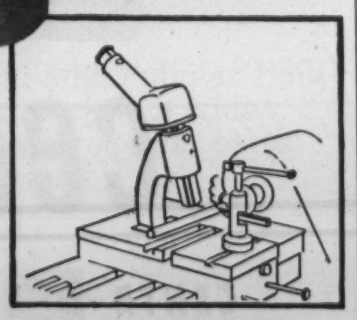
Find out how this inexpensive production tool can lower your manufacturing costs. WRITE, WIRE or PHONE today for free demonstrations and Data Bulletin D1052. Bausch & Lomb Optical Co., 79301 St. Paul St., Rochester 2, N. Y. (Phone: LOcust 3000).



Use it in tripod...



in microscope stand...



...or even built into machinery!

BAUSCH & LOMB

SINCE B&L 1853

AMERICA'S ONLY COMPLETE OPTICAL SOURCE ... FROM GLASS TO FINISHED PRODUCT

For more information, turn to Reader Service Card, Circle No. 320

OTHER NEW MATERIALS, PRODUCTS

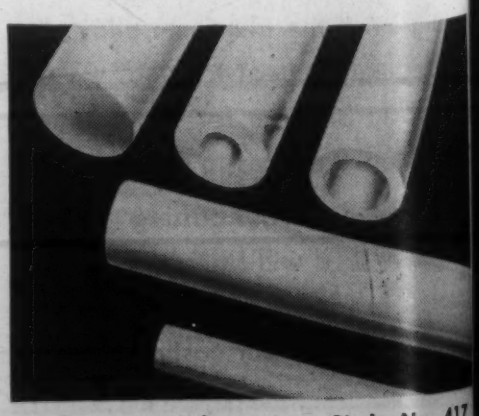
properties, and moldability which may permit elimination of preforming. The material is being manufactured as Mofelt by *Charles Lachman Co., Inc.*, subsidiary of Mohawk Carpet Mills, Inc., Franklin and Grant Sts., Phoenixville, Pa., and as Troytuf by *Troy Blanket Mills*, 200 Madison Ave., New York 16.

Homogeneity of the material is said to permit fabrication of laminates of uniform thickness, smooth surface and equal strength in all directions. The batting can be deep drawn, eliminating necessity for preforming for many applications. The favorable strength-to-weight ratio of the synthetic materials results in lighter laminates. The fibers have low moisture absorption, good chemical resistance, dielectric strength, abrasion and impact resistance, weatherability and translucency. The material is available in any of the three fibers and in a variety of weights and widths, adaptable for either overlay or total reinforcement.

Fluorocarbon Rod, Tube and Backing Rings

Rod and tube of Kelon-F (M. W. Kellogg's Kel-F and Bakelite's Fluorothene), and back-up rings of Kelon-T Du Pont's Teflon) are now available in production quantities from *Shamban Engineering Co.*, 11617 W. Jefferson Blvd., Culver City, Calif.

The molded Kelon-F rod is available in sizes from 5/8 to 5 in. o.d. and the tubing in wall thicknesses from 3/8 in. Rod and tubing



For more information, Circle No. 417

what's new?

NUMBER 32 OF A SERIES

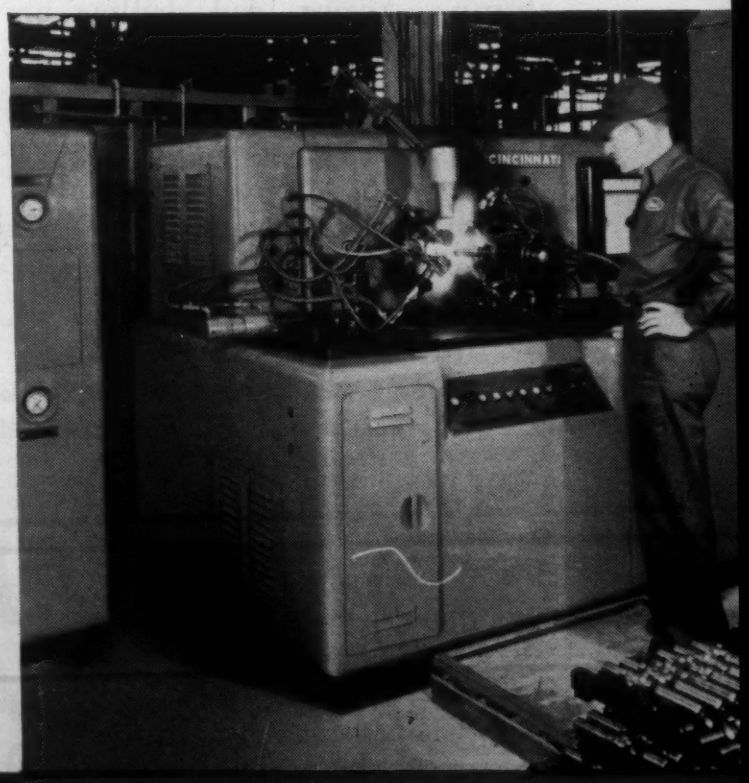
seven hardening jobs on one flamatic

You might look for a lot of fancy tooling on the Standard Flamatic that hardens all these jobs. You won't find it.

Instead, you'll find a single, work-holding fixture and two pairs of standard flame heads, changed over in minutes to switch from one job to the next. These parts are made by a manufacturer of automotive transmissions whose schedules and varying lot sizes make the heat treating virtually a job-shop operation.

Flamatic keeps the pace, maintains part-to-part uniformity, holds costs in line, and gives the maintenance people practically no trouble. Flamatic holds temperatures in line with electronic control, operation is pushbutton except for loading.

To find out how versatile Flamatic selective hardening can be, write for Publication No. M-1861.



CINCINNATI **flamatic**

PROCESS MACHINERY DIVISION
THE CINCINNATI MILLING MACHINE CO.
CINCINNATI 9, OHIO, U.S.A.

PACING INDUSTRY WITH RESEARCH

Chief Sandusky

FERROUS AND NON-FERROUS CENTRIFUGALLY CAST SLEEVES, ROLLS, LINERS, TUBES, RETORTS, CHUTES, RINGS, BUSHINGS, BEARINGS, ETC.

Our continuing development program is a major factor in meeting your ever increasing demands for ferrous and non-ferrous centrifugal castings. And research is a vital phase in keeping ahead of your requirements.

Precise metallurgical control is maintained throughout the entire manufacturing process to produce strong, uniform, close-grained castings which are extremely resistant to heat, corrosion, and abrasion. Excellent machining facilities for turning, boring, and drilling are also available.

You can rely on Chief Sandusky as a versatile integrated centrifugal specialist where castings are produced to your specific requirements with modern, up-to-date equipment.

C. M. Lovsted & Co., Seattle, Wash. • Tynes Bros., Birmingham, Ala. • Cordes Bros., San Francisco and Wilmington, Calif.

Chief SANDUSKY CENTRIFUGAL CASTINGS

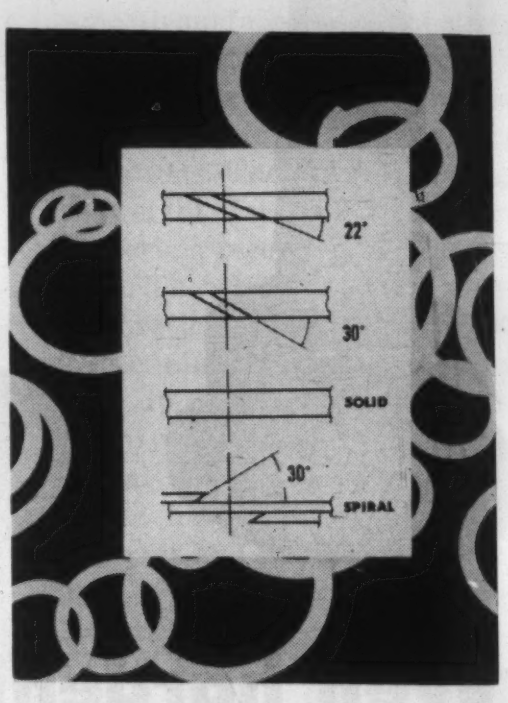
FERROUS AND NON-FERROUS

SANDUSKY FOUNDRY AND MACHINE CO., Sandusky, Ohio

For more information, turn to Reader Service Card, Circle No. 361

OTHER NEW MATERIALS, PRODUCTS

are X-ray inspected after production to detect defects or porosity. With excellent chemical, electrical and thermal characteristics, the materials are suitable for applications involving severe corrosive chemicals, and temperatures from —300 to 400 F in continuous service. Typical applications include aerial supports, antenna spacers, coaxial spacers, special coil forms, gaskets, low temperature seals, O-rings, probes, and valve seats.



Kelon-T backup rings are available solid, solid with 22 deg or 30 deg cut, and spiral. They are designed to solve tough sealing problems in hydraulic and pneumatic installations. Rings protect O-rings seals from extrusion or loss of efficiency. The new packings have very low friction qualities, are chemically inert and have an operating range of —100 to 500 F. Sizes of backups correspond to sizes of both MS and AN O-rings and back-ups, though special sizes are available on order.

Casting Resin Has High Heat Distortion

A new thermoplastic casting resin, designated LC-601, which can be cured at room temperature or with heat and is said to have a heat distortion point of 260 F, has

The new foam that makes good products better

VINYL foam

FOR CUSHIONING

FOR SAFETY PADDING

FOR HEAT-SEALED PRODUCTS

Now—when you want the ultimate in *resilient comfort*, the answer is VINYLFOAM. When you want to *simplify complicated assemblies*, the answer is VINYLFOAM . When you want the ideal foam for *heat-sealed products*, the answer is VINYLFOAM.

The chances are your present key suppliers are among our licensees, who will confer with you on how VINYLFOAM can be adapted to your specifications. Its fire-resistance, versatility and other features will give you new competitive advantages and reduce production costs.

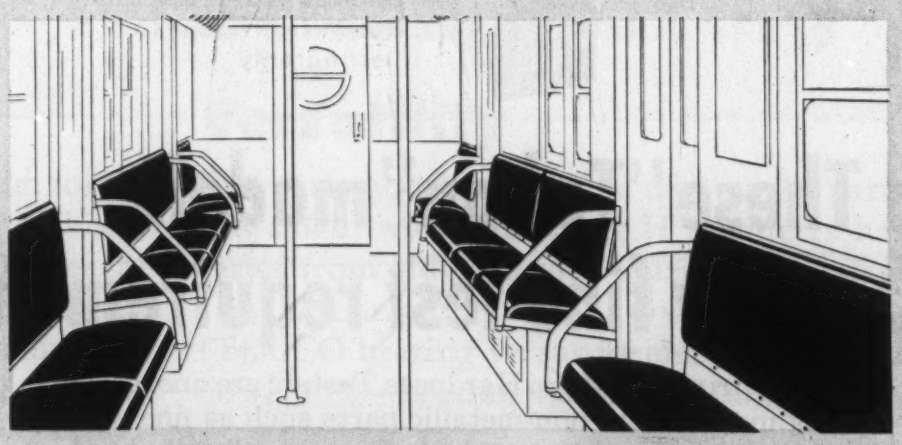


Illustration shows New York City subway car seats cushioned with VINYLFOAM

ELASTOMER PROCESS VF VINYLFOAM

VINYLFOAM is the fire-resistant foam for contoured cushions, cored or uncored, for public transportation seating.

U.S. PRODUCTION LICENSEES (Partial List)

Brown Rubber Company.....Lafayette, Ind.
Cambridge Rubber Company.....Taneytown, Md.
L. E. Carpenter & Company.....Wharton, N. J.
Dunlop Tire & Rubber Corp.....Buffalo, N. Y.
Federal Leather Company.....Belleville, N. J.
Firestone Tire & Rubber Company.....Akron, O.
General Tire & Rubber Co.....Lawrence, Mass.
B. F. Goodrich Company.....Shelton, Conn.
Great American Industries.....Bedford, Va.
Hood Sponge Rubber Company.....Chicago, Ill.
Kyfoam Incorporated.....Louisville, Ky.
Nopco Chemical Co.....Harrison, N. J.
Seiberling Rubber Company.....Akron, O.
Sheller Manufacturing Company.....Keokuk, Ia.
Sun Rubber Company.....Barberton, O.
U.S. Rubber Company.....Mishawaka, Ind.

U.S. EXPERIMENTAL LICENSEES

Bakelite Company.....Pittsburgh, Pa.
Firestone Plastics Company.....Pottstown, Pa.
B. F. Goodrich Chemical Co.....Cleveland, O.
The Girdler Company.....Louisville, Ky.
Monsanto Chemical Company.....St. Louis, Mo.

CANADIAN AND OVERSEAS PRODUCTION LICENSEES

British Rubber Company.....Montreal, Que.
Dunlop Canada Limited.....Toronto, Ont.
H. F. Products, Ltd.....Montreal, Que.
Robinson Moulded Products...Woodbridge, Ont.
Le Laboureur.....Wattrelos, France
Les Etablissements Marechal.....Paris, France
Svenska Gummifabriks AB.....Gislaved, Sweden

EXCLUSIVE OVERSEAS LICENSING AGENT

The Girdler Company.....Louisville, Ky.

COPYRIGHT 1955 BY

ELASTOMER CHEMICAL CORPORATION • 212 WRIGHT ST., NEWARK 5, N. J. • BIGELOW 8-3888

*For more information, turn to Reader Service Card, Circle No. 390

ACCO products

Wilson "Tukon" Micro Hardness Testers

These "Tukon" models meet every fine test requirement

• WILSON "TUKON" Micro Hardness Testers are unexcelled for testing metallic and non-metallic parts such as fine wire, small precision parts, thin metal, shallow superficially hardened surfaces, jewels, plastics, glass, etc.

The three models pictured cover the entire range of diamond pyramid testing—with both Knoop and 136 degree Diamond Pyramid Indentors.

Proper selection of the proper model for your particular requirement depends on the type and thickness of work to be tested, range of loads, purposes for which the machine is to be used—research or control, other hardness testing equipment available and whether a combination of micro and macro hardness testing is required.

We invite you to consult with WILSON engineers on your hardness testing problem. There is no obligation. Write for **Booklet DH-114** *on WILSON "TUKON" Micro Hardness Testers.*

ACCO Wilson Mechanical Instrument Division
AMERICAN CHAIN & CABLE
230-E Park Avenue, New York 17, N. Y.

WILSON "ROCKWELL" and "TUKON" Hardness Testers

For more information, turn to Reader Service Card, Circle No. 367

OTHER NEW MATERIALS, PRODUCTS

TYPICAL PROPERTIES OF LC-601 CASTING RESIN

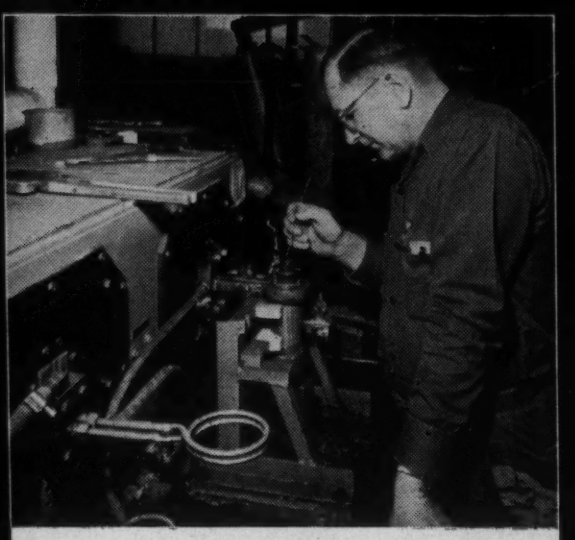
Ten str, psi	8500
Comp str, psi	9500
Impact str, notched Izod, ft-lb/in. notch	0.6
Hardness, Rm	86
Heat dist, F	260
Forming temp, F	350
Modulus, psi	8×10^5
Water absorp, %	0.05
Dielect const	2.8—3.2
Resistivity	10^{15}
Dissip, 60 cycles	0.005
Dissip, 10 mcs	0.002
Dielect str, v/mil	550
Viscosity, mixed, cps	<50
Pot life, hr	2
Set time, hr	4
80% strength, hr	12
Shrinkage, %	1
Adhesion to metals, psi	100—500
Adhesion to plastics, psi	300—1000
Adhesion to wood	Good
Air inhibition	None

been developed by *Louis Laboratories*, 175 W. 97th St., New York 25. Said to be a new polymer, the resin is a low viscosity liquid which can be thickened into a moldable putty. It is said to cure with negligible shrinkage and low exotherm and to possess high electrical characteristics. Pot life can range from minutes to hours and the material contains no skin irritants or flammable components. It is said to have a smooth glossy surface when cured either in the mold or in air. It is fully postformable at 350 F. It is weldable, machines easily, has a low coefficient of friction, and negligible water absorption. When filled with Garan - finished chopped - strand glass fibers, strength is said to be considerably improved.

Molded Rubber Parts

Molded rubber parts, custom-produced to specification, are available in a wide range of rubber compounds, either natural or synthetic, from *Quality Rubber and Transmission Co.*, Dept. MMN, 2203 W. Chicago Ave., Chicago 22. Typical parts include

JACK & HEINTZ Saves $15.84 per hour...



Jack & Heintz Inc. silver brazes over 25 different parts on this 15 KW, 10,000 cycle TOCCO machine.

with TOCCO* Induction Brazing

Brazing Costs Down

When Jack & Heintz engineers switched from torch brazing to automatic induction, brazing cost of these inverter brush mounts fell from $.05 to $.006 each —a reduction of 83% in direct labor costs alone! Additional savings result because less cleaning is required after TOCCO, and fuel costs are much lower, too.

Brazing Production Up

While costs dropped, production on the part zoomed —from 40 to 360 brazed assemblies per hour. Furthermore, rejects and scrap, formerly high, are now negligible.

Versatility

The part shown is just one of over 25 parts, large and small, which alert J & H engineers have converted from old-fashioned brazing methods to modern, automatic TOCCO. Overall brazing costs (TOCCO brazing versus former methods used) are down 75%—brazing speed, up 100%.

* * *

If the manufacture of *your* product involves brazing, heat-treating, forging or melting of ferrous or nonferrous metals, don't overlook TOCCO as a sound method of increasing production, improving product quality and slashing costs.

THE OHIO CRANKSHAFT COMPANY

TOCCO

*Trade Mark Reg. U. S. Pat. Off.

Mail Coupon Today

NEW FREE BULLETIN

THE OHIO CRANKSHAFT CO.
Dept. T-1 Cleveland 5, Ohio

Please send copy of "Typical Results of TOCCO Induction Brazing and Soldering".

Name_____

Position_____

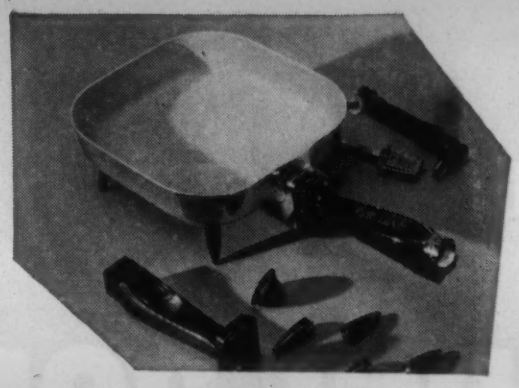
Company_____

Address_____

City_____ Zone____ State_____

For more information, turn to Reader Service Card, Circle No. 362

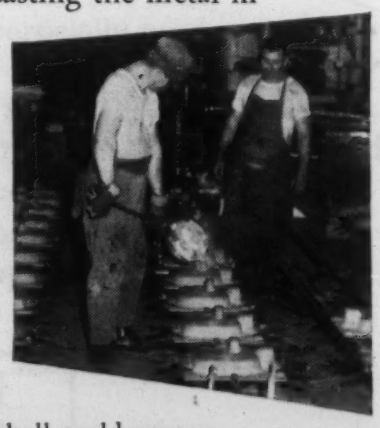
PRODUCT DESIGN WITH DUREZ PHENOLICS



Fry Pan's HEATER *is* CAST-IN

what can our phenolics help YOU do better?

● Many a trail leading to manufacturing short cuts and better product service is being blazed with Durez phenolics—the basic engineering plastics. One of recent note resulted in this fry pan with its electric unit molded right into the metal casting during the shell molding operation. Casting the metal in shells bonded with Durez resins, this manufacturer reduced assembly and machining operations, saved on labor costs, and practically eliminated spoilage. Then he finished off a superior product with a beautiful jet-black, heat-resistant handle, legs, and cover knob molded of Durez phenolic plastic.



Durez phenolic resins or molding compounds, or both, could help you solve design or production problems that no other material can do so well. Talk with your molder . . . or call on our technical field men.

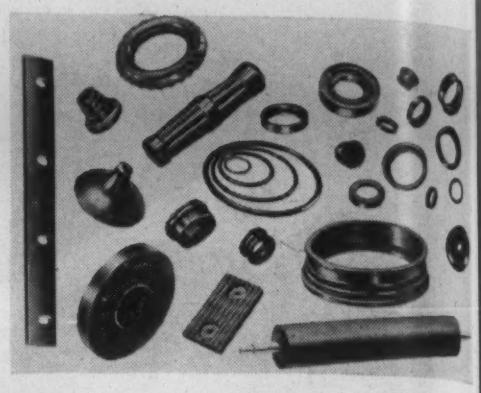
IF YOU ARE interested in casting by the shell mold process ask for our "Guide to Shell Molding". If you are interested in formed plastic parts, ask for "Facts on Phenolics".

DUREZ®

DUREZ PLASTICS DIVISION
HOOKER ELECTROCHEMICAL COMPANY
Phenolic molding materials and phenolic resins that fit the job
HOOKER CHEMICALS
1401 WALCK ROAD, NORTH TONAWANDA, N. Y.

For more information, turn to Reader Service Card, Circle No. 453

OTHER NEW MATERIALS, PRODUCTS



air brake diaphragms, bumpers and snubbers, rubber wheels, gaskets, spring inserts, oil seals, O-rings, rubber covered rolls and idlers, regulator diaphragms and radio and television parts. Quality control is said to be closely maintained over compounding, specific gravity, compression set, durability, scorch, elongation and shrinkage, hardness, tensile strength and modulus.

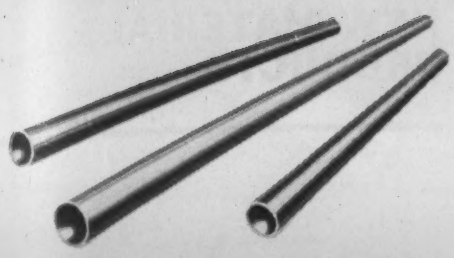
Thermostat Bimetal

A thermostat bimetal with a wide range of linear deflections between —100 and 800 F has been added to the line of thermostat bimetals marketed by *American Silver Co.*, 36-07 Prince St., Flushing 54, N. Y. Designated ASC-3, it has a maximum sensitivity of 200 to 600 F, and is produced in thicknesses down to 0.001 in., widths down to 0.093 in., in coils or lengths cut to order. It is said to be finding uses in such equipment as appliance cord controls, coffee makers, electric toasters, refrigerators, electric ranges, ironing machines and in nuclear, and meteorological electronic equipment.

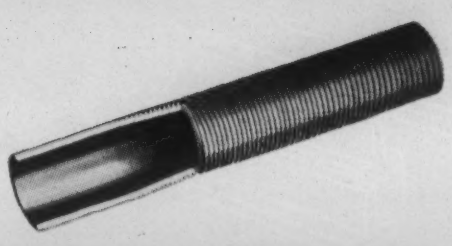
Nylon Fittings for Plastics or Metal Tube

Nylon fittings, designed for use with tubing made of nylon, polyethylene, aluminum, steel or copper, are being marketed by *The Imperial Brass Mfg. Co.*, 1200 W. Harrison St., Chicago 7, under

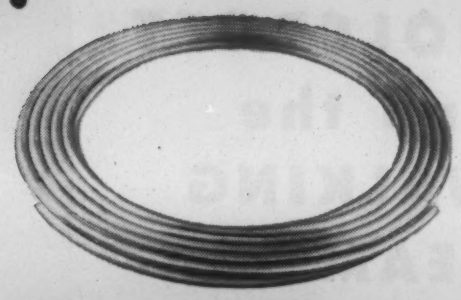
Here's What We Do!



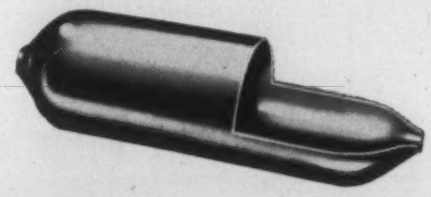
Wolverine manufactures plain tube in copper and aluminum in a wide range of sizes and alloys. Aluminum tube can be provided as drawn or extruded.



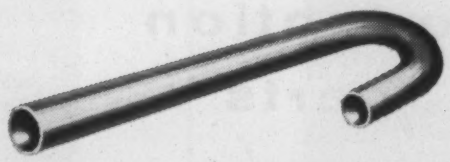
Wolverine Trufin*—the integral finned tube—will save space, step up efficiency in heat exchange operations.



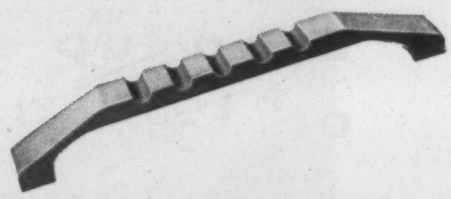
Wolverine plain tube can be furnished in easy-to-handle coils or exact straight lengths.



Wolverine through its exclusive Spun End Process** manufactures dependable, one-piece tubular-shaped parts, spun completely or partially closed to your specifications.

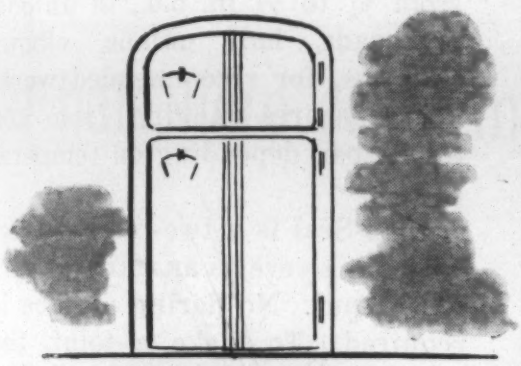


Wolverine can bend, spin, flare, bead, expand, reduce or otherwise fabricate tubing to your requirements.

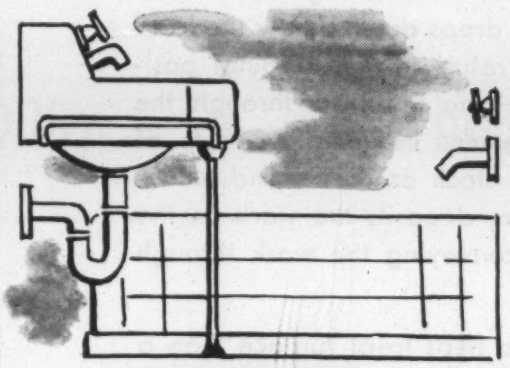


Wolverine also specializes in the manufacture of extruded aluminum shapes.

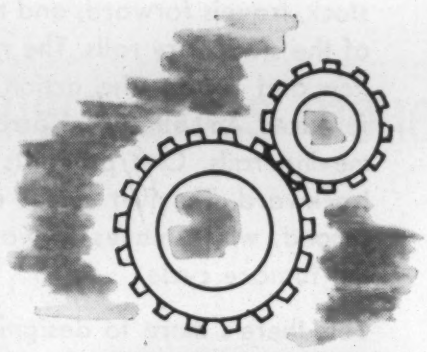
What Do You Do?



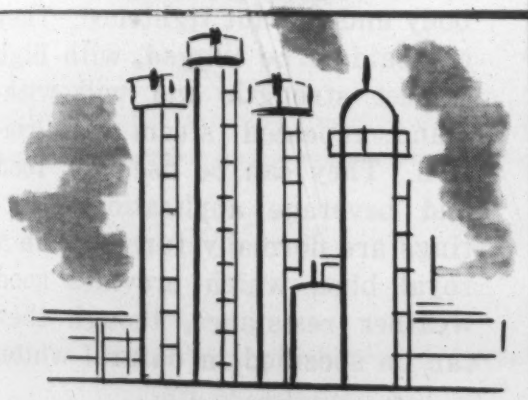
REFRIGERATION



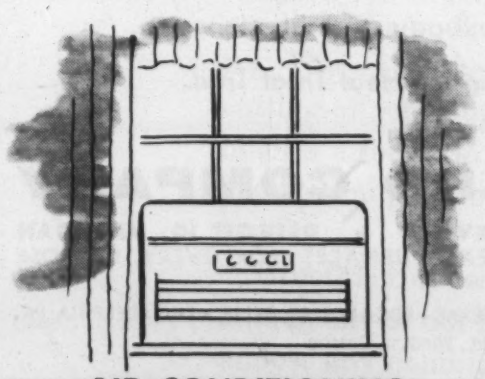
CONSTRUCTION



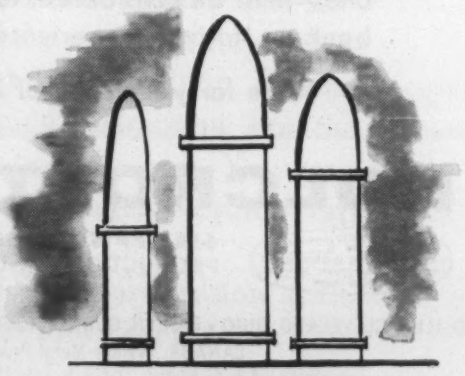
MANUFACTURING



PROCESSING



AIR CONDITIONING



ORDNANCE

Why Don't We Get Together?

If you are using tube, tubular-shaped products, or extruded aluminum shapes, it's sure as shooting that Wolverine can help save you time and money. You can get quick help from Wolverine's Field Engineering Service—a group of tube technicians who have the answers. Write for Wolverine's General Products Catalog—*right now!*
WOLVERINE TUBE, 1439 Central Avenue, Detroit 9, Michigan.

Wolverine Trufin is available in Canada through the Unifin Tube Company, London, Ontario.

*REGISTERED U.S. PAT. OFF.
**A PATENTED PROCESS RE. 22465

WOLVERINE TUBE

Division of Calumet & Hecla, Inc.

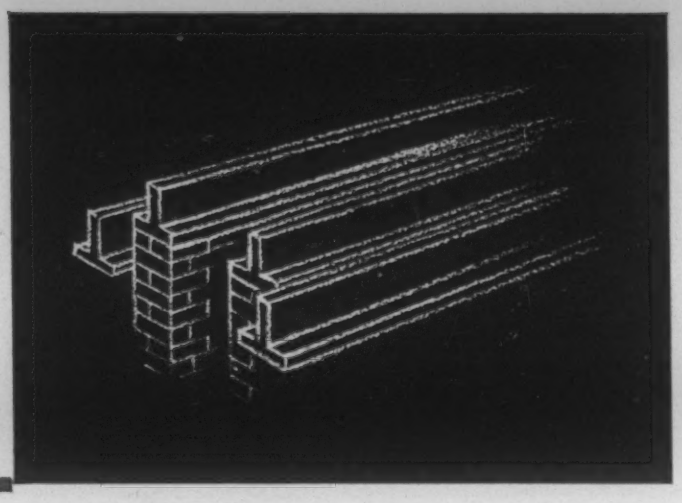
MANUFACTURERS OF QUALITY-CONTROLLED TUBING AND EXTRUDED ALUMINUM SHAPES

PLANTS IN DETROIT, MICHIGAN, AND DECATUR, ALABAMA. SALES OFFICES IN PRINCIPAL CITIES

EXPORT DEPARTMENT, 13 EAST 40TH STREET, NEW YORK 16, NEW YORK

For more information, turn to Reader Service Card, Circle No. 356

HOLCROFT and the WALKING BEAM FURNACE



Step up production of l-o-n-g parts

The walking beam furnace is an automatic, high production furnace usually used for treating bar stock, tubes, axles, and similarly shaped products.

Stock handling is ingenious. Two sets of rails—one stationary—run the length of the furnace. The moving set lifts the stock, travels forward, and then drops down below the level of the stationary rails. The rails return to their original position and repeat the action, walking the work through the furnace. An alternate arrangement includes two sets of moving rails. One pair lifts the stock as the second moves backward. The first comes down, deposits the work on the second, which moves forward conveying the work through the furnace cycle.

Yes, there's more to designing a heat treat furnace than a knowledge of metallurgy. Other factors—stock handling for one—must be considered, too. That's why it's a good bet to bank on Holcroft experience. It will pay off in the long run.

Write for your copy of Blazing the Heat Treat Trail.

HOLCROFT AND COMPANY

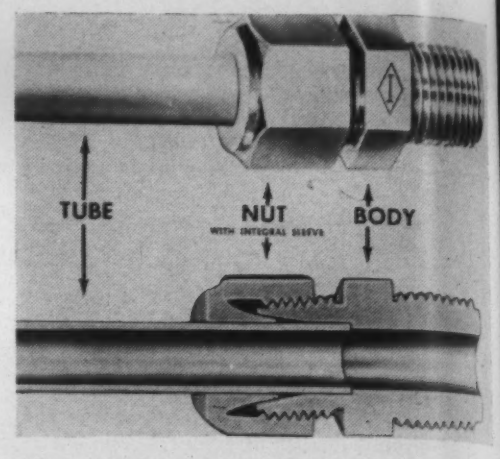
BUILT BY HOLCROFT & COMPANY DETROIT · MICH

6545 EPWORTH BOULEVARD • DETROIT 10, MICHIGAN
PRODUCTION HEAT TREAT FURNACES FOR EVERY PURPOSE

CHICAGO, ILL. • CLEVELAND, OHIO • DARIEN, CONN. • HOUSTON, TEXAS • LOS ANGELES, CALIF. • PHILADELPHIA, PA.
CANADA: Walker Metal Products, Ltd., Windsor, Ontario

For more information, turn to Reader Service Card, Circle No. 354

OTHER NEW MATERIALS, PRODUCTS

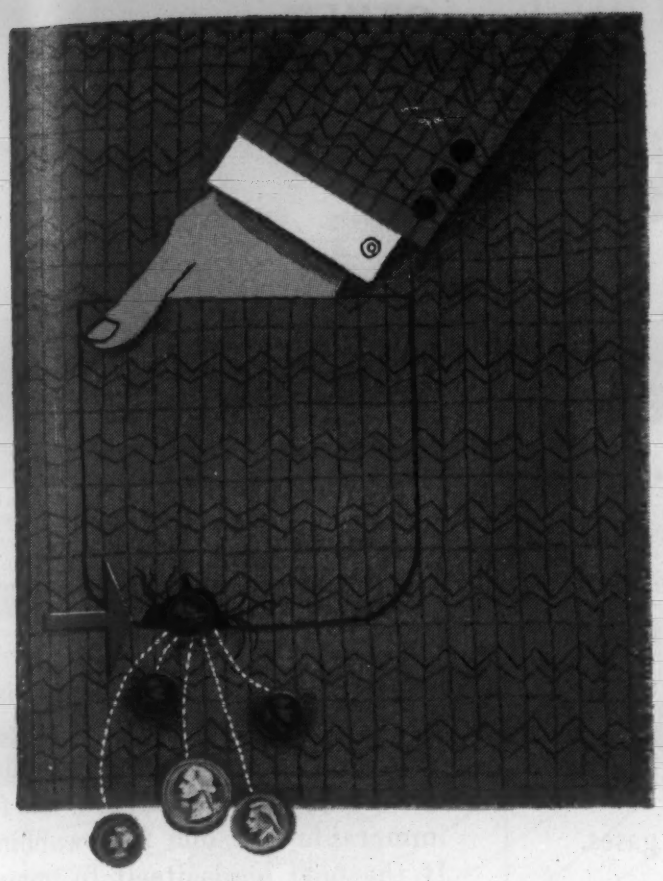


the trade name Nylo-Seal. They are said to be impervious to most acids and alkalis and will withstand temperatures from —70 to 250 F. They are available in sizes from ¼ to ½ in. o.d., in unions, bulkheads, half unions, elbows and tees, for recommended working pressures ranging from 150 to 500 psi, depending on temperature.

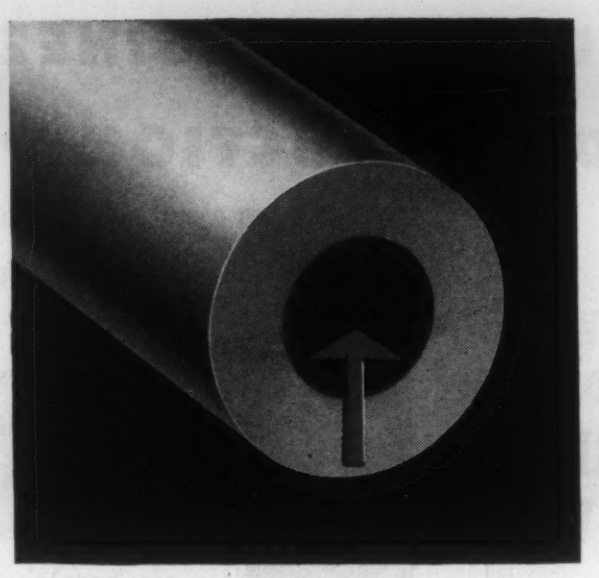
Nylo-Seal is a two-piece fitting, with the sleeve as an integral part of the nut. No flaring of tube is required. To make a joint, the tube is inserted into the fitting body and the nut tightened. They are said to be rugged, with high impact strength and will withstand repeated steam sterilization. They can be used for food and beverage applications. Fittings are normally furnished in a royal blue, which provides good weather resistance, though they can be specified in natural white.

Blacking for Aluminum

Additional information is now available on Alumblack, a cold chemical type blacking finish for aluminum (see MATERIALS & METHODS, November, p. 162). Primary advantages claimed for the finish are ease of application and the ability to use the material in touching up unfinished or damaged areas. Developed by *Birchwood Chemical Co.*, 4500 W. 44th St., Minneapolis, the finish can be used to provide a lustrous black surface, a dull, non-reflective



a hole here costs money...



a hole here saves money

Crucible Hollow Tool Steel Bars put savings into the pockets of the metalworking industry. There's no need for costly drilling, boring, cutting-off or rough-facing operations. For the hole is already in the steel you buy. You save production time, machine capacity—avoid scrap losses.

Crucible Hollow Tool Steel Bars are now available in any of our famous tool steel grades . . . in almost any combination of O.D. and I.D. sizes. And you get *immediate* delivery of five popular grades — KETOS oil-hardening, SANDERSON water-hardening, AIRDI 150 high-carbon high-chromium, AIRKOOL air-hardening, and NU DIE V hot-work tool steels.

Your Crucible representative can show you how to save time and money with Crucible Hollow Tool Steel Bars. *Crucible Steel Company of America, Oliver Building, Pittsburgh 30, Pa.*

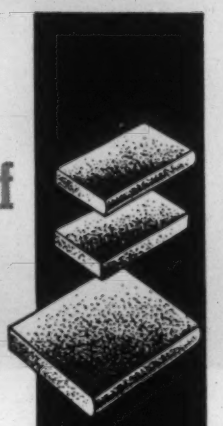
CRUCIBLE **first name in special purpose steels**

Crucible Steel Company of America

For more information, turn to Reader Service Card, Circle No. 431

CARBON SOLVES DESIGN, ENGINEERING, AND PRODUCTION PROBLEMS

Light weight, corrosion-proof CARBON PUMP VANES

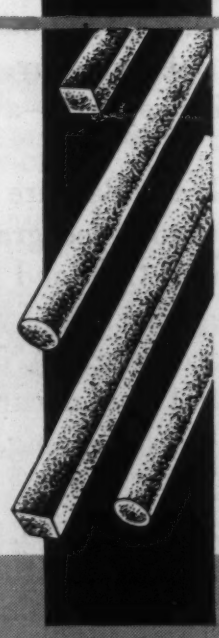


Vanes of Stackpole carbon-graphite for automotive rotating pumps are low in cost, light in weight and are made to close tolerances. Thanks to their chemical inertness, self-lubricating qualities and other factors, they are ideally suited for pumping air, corrosive chemicals or gases.

OIL SEALS that minimize pitting and blistering

Molded from carbon and graphite sometimes balanced with resins or metal powders to meet specific operating requirements, Stackpole seal rings are available in grades, types and sizes for almost any need. Recently developed grades greatly minimize pitting and blistering.

CARBON RODS for salt bath rectification



Stackpole rods are highly effective in avoiding decarburization of metal in heat treating by electric salt baths. Furnace electrode life is increased 4 to 6 times. Sludge formation and salt "drag out" are minimized. Greater fluidity of bath assures much faster, completely uniform heating.

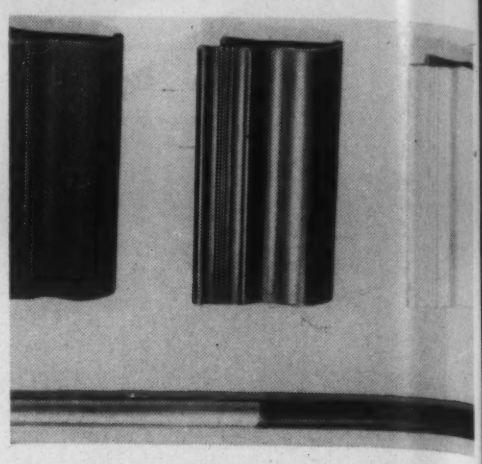
STACKPOLE CARBON COMPANY
St. Marys, Pa.

STACKPOLE

Quality Products—backed by the keen personal interest and cooperation of the specialists who engineer them

For more information, turn to Reader Service Card, Circle No. 323

OTHER NEW MATERIALS, PRODUCTS



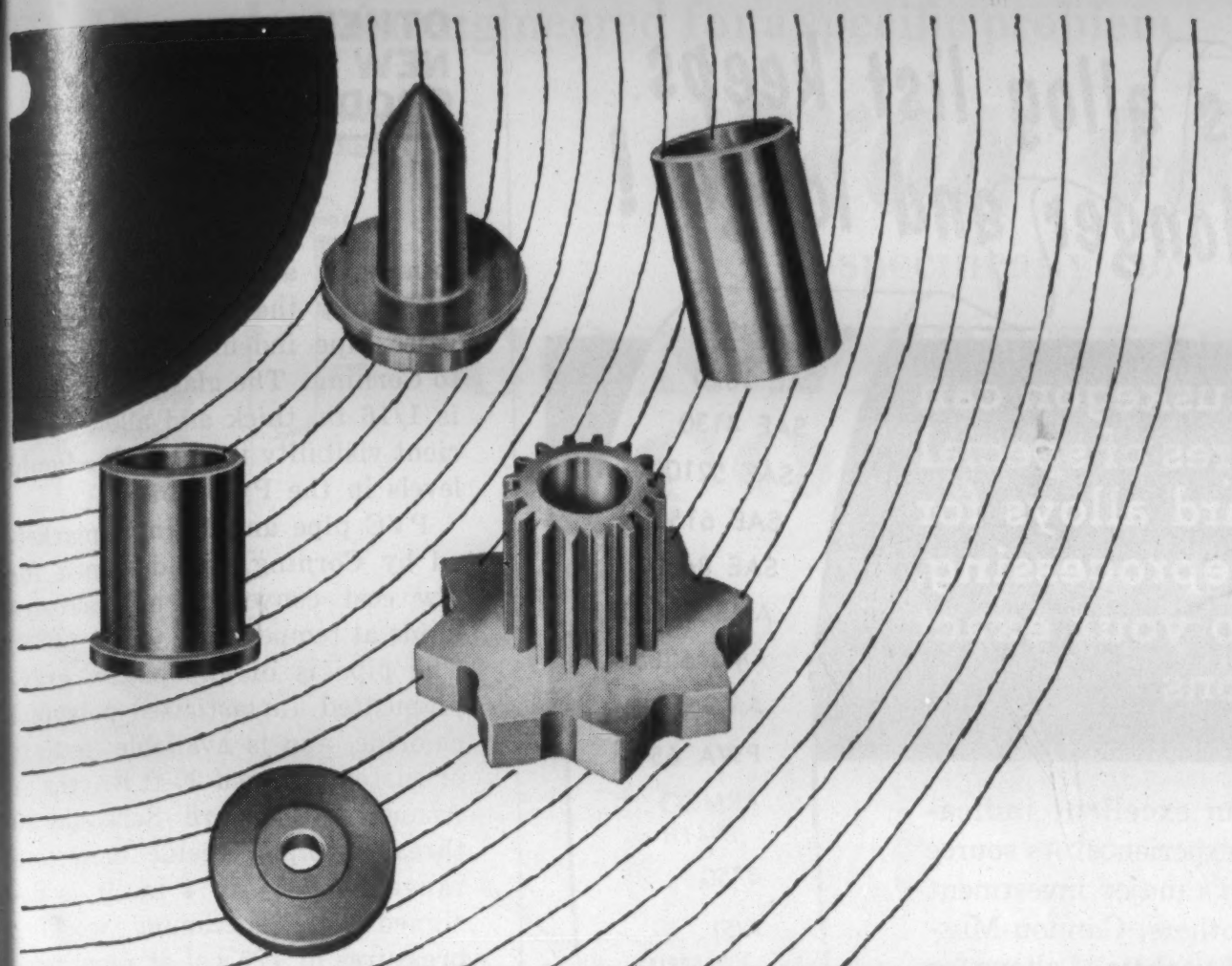
black finish or an iridescent finish.

Two formulations are in general use for aluminum, depending on the application method, one for immersion and one for swabbing. If the part lends itself to immersion, it is dipped in the solution for 5 to 15 sec, depending on the alloy, then removed and rinsed. If a bright surface is required, the finish should be thoroughly dryed and polished by light buffing or by tumbling. The formulation for swabbing is particularly useful for touch-up and repair work. Only normal cleaning is necessary prior to finishing. If a smooth, lustrous surface is desired, metal should be polished before applying the finish. The finish can be removed by brisk cleaning with steel wool.

Plastics and Glass Pipe

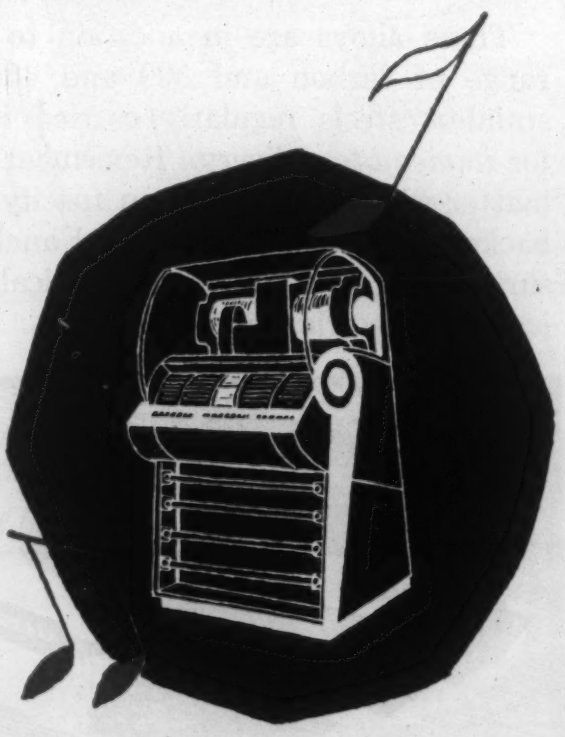
Two new types of pipe for corrosion-resistant applications are being marketed by *Corning Glass Works*, Corning, N. Y. They are: 1) Pyrex brand glass pipe protected against rough handling by a sleeve of glass-reinforced polyester resin, and 2) polyvinyl pipe and fittings.

The seamless sleeve of polyester resin reinforced with glass cloth fits snugly over the Pyrex pipe and is cut to fit the length of the pipe. The jacket is nonflammable, corrosion resistant, unaffected by weather, moisture or rodents, and has a maximum operating temperature of 300 F. In case of failure of the glass pipe, drippage from the sleeve will be held to a



sound from silence . . . .

The J. P. Seeburg Corp. has worked hand in hand with The United States Graphite Company in developing self lubricating bearings and parts which meet the exacting requirements of the most successful high fidelity coin operated phonograph made today.



GRAMIX®

products from powder metallurgy

112

THE UNITED STATES GRAPHITE COMPANY

DIVISION OF THE WICKES CORPORATION • SAGINAW, MICHIGAN

For more information, turn to Reader Service Card, Circle No. 395

"This alloy list keeps getting longer and longer!

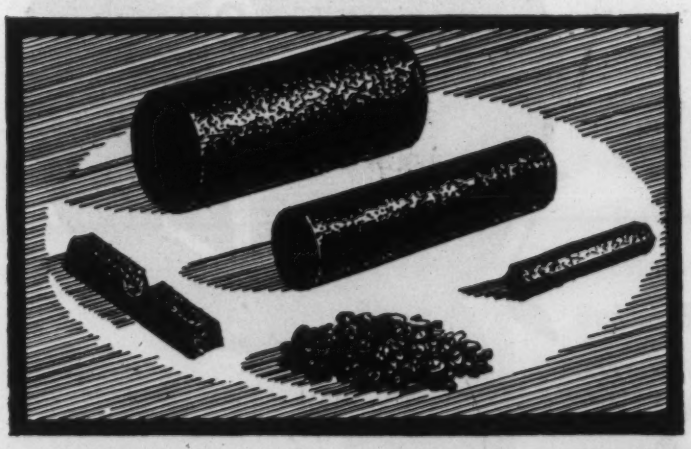
Cannon-Muskegon can supply scores of special and standard alloys for remelt or reprocessing, certified to your exact specifications

A *long* alloy list is an excellent indication of long alloy experience! As source for many of the nation's major investment casting suppliers and others, Cannon-Muskegon furnishes a great variety of alloys for remelt or reprocessing. Alloys include super stainless and tool steels, as well as nickel and cobalt-base alloys. Other alloys are prepared specially for medical, aeronautical, electronic, industrial and experimental uses.

These alloys are in addition to a wide range of carbon and 300 and 400 series stainless steels regularly carried in stock for *immediate* delivery. Remember . . . no matter what type alloy you specify each is backed with a notarized metal analysis insuring *exactly predictable* physical, chemical and electrical properties.

- *NI RESIST
- SAE 1020
- SAE 4130
- SAE 52100
- SAE 6150
- SAE 8630
- AMS 5382B
- AMS 5385B
- AMS 5388
- PWA 651
- ARMCO 17-4-PH
- 4750
- AISI 300 SERIES
- AISI 400 SERIES
- *MONEL
- *INCONEL
- ACI-H7
- 18-4-1
- IIB2
- IID2
- INVAR
- CO-CR-W ALLOYS
- CU-NI ALLOYS
- NI-CR ALLOYS
- NI-FE ALLOYS
- NI-CR-FE ALLOYS
- CR-FE ALLOYS

*®International Nickel Co.



MASTERMET ALLOYS are available in either ingot, shot, hexagon bar, billet or 12"-long, 6" diameter cast round bar form. Alloys are shipped in drums with specifications clearly imprinted for fast selection and storage.

WRITE for your copy of New MasterMet Bulletin and technical data on the complete MasterMet alloy service.

Cannon-Muskegon
CORPORATION
2873 Lincoln Street • Muskegon, Michigan

MASTERMET

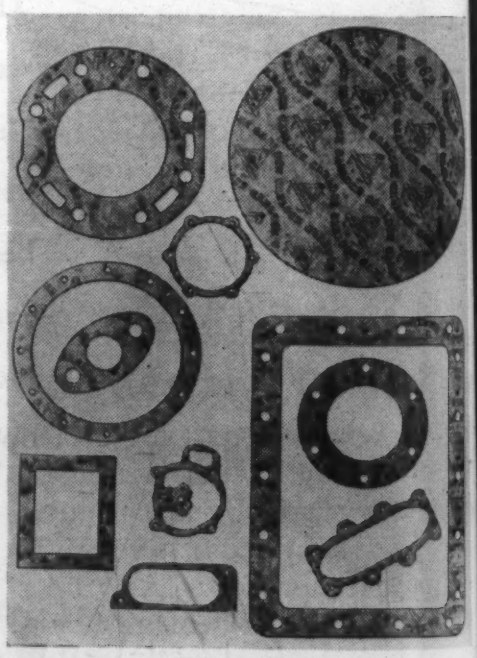
METALLURGICAL SPECIALISTS

For more information, turn to Reader Service Card, Circle No. 315

OTHER NEW MATERIALS, PRODUCTS

minimum, and the sleeve itself will carry the rated load of the glass pipe indefinitely, according to Corning. The glass-resin sleeve is 1/16 in. thick and allows sufficient visibility to determine liquid levels in the Pyrex pipe.

PVC pipe and fittings, marketed by Corning, are designed for low cost conveying of corrosive fluids at temperature under 140 F. The pipe is of an opaque, gray-pigmented unplasticized polyvinyl chloride, and is available in 10-ft or custom-ordered 20-ft lengths of American Standard Schedule 80 threaded pipe. Inside diameters range from ½ to 4 in. It is designed for maximum working pressures of 125 psi at room temperature, and can be cut, sawed, and threaded with conventional pipe tools. It can also be bent into different shapes after oven heating to 260-275 F.



Gasket Material for Use Up to 300 F

A gasketing material consisting of a cork-base paper impregnated with Chemigum Latex is said to provide a tight seal where harmful liquids are encountered. Developed primarily for use in oil and chemical processing industries, Garlock 662 can be used for

EXON: each resin engineered for a specific problem

EXON 481

specifically for

CONSTRUCTION COATINGS

Site application of colorful, abrasion-proof coatings that last is now possible with the development of EXON 481 resin.

Simply sprayed on by a gun with 60 lbs. pressure over a prime coat, the stainproof, scuffproof sheeting dries the instant it is applied. Application is so quick and easy that the most complex shapes are no problem. No loose ends, seams, laps or joints.

EXON 481 has exceptional tensile strength — over 1000 lbs. per square inch with an elongation factor up to 200%. It is soluble in ketones, compatible with plasticizers, stabilizers and all pigment types.

As a result, coatings of the most decorative, attractive colors can be formulated. All completely washable, they ruggedly resist fading or cracking.

Firestone

EXON®

For complete information or technical service on EXON *481 and on all the resins in the ever-growing* EXON *line, call or write:*

CHEMICAL SALES DIVISION

FIRESTONE PLASTICS COMPANY, DEPT. 63 C, POTTSTOWN, PA.
DIVISION OF FIRESTONE TIRE & RUBBER CO.

For more information, turn to Reader Service Card, Circle No. 329

Make
high-strength
aluminum castings
without heat treatment!

Foundries without heat treating facilities are producing high-strength aluminum castings with Federated's Tenzaloy. Mechanical properties are equivalent or superior to the common heat-treated alloys, and impact strength is greater.

Tenzaloy, a product of Federated research, is a self-aging alloy of the aluminum-zinc-magnesium type. It reaches full strength after a few days aging at room temperature. No special casting precautions or facilities are required.

Tenzaloy castings have excellent machinability. They can be anodized to a superior white color. Tenzaloy is one of the few casting alloys that can be brazed at high temperature. It has corrosion resistance equal to or better than the aluminum-silicon alloys.

If your heat treating facilities are inadequate or too costly, or if you are paying for outside work, or if you are casting large and complex aluminum shapes which cannot be conveniently heat treated, call Federated for more information on modern Tenzaloy. Any of our 13 plants and 23 sales offices across the country is ready to help.

Federated Metals

DIVISION OF AMERICAN SMELTING AND REFINING COMPANY
120 BROADWAY, NEW YORK 5, N. Y.
IN CANADA: FEDERATED METALS CANADA, LTD., TORONTO AND MONTREAL

Federated first in the non ferrous field FMD

For more information, turn to Reader Service Card, Circle No. 363

OTHER NEW MATERIALS, PRODUCTS

gasketing at temperatures as high as 300 F. Manufactured by *Garlock Packing Co.*, Palmyra, N. Y., the material is not susceptible to changes in moisture content, thus will not shrink. Elimination of shrinkage permits precutting of gaskets far in advance of use. The latex binder provides resistance to humidity, high temperatures and aging. Sheets or cut gaskets are available in thicknesses from 0.01 to 0.25 in. and cut gaskets are produced in a variety of shapes and sizes with outside dimensions up to 48 in.

Punching Grade Epoxy Laminate

A non-crazing, cold punching grade epoxy-glass laminate has been developed by *Mica Corp.*, 4031 Elenda St., Culver City, Calif. The laminate, called Micaply Epoxy-Glass, is said to combine high strength, low moisture absorption and high electrical properties with resistance to inorganic acids and organic solvents. When laminated with copper, the material can be etched for printed circuits, or it can be used as a base for commutators, binary code discs and other electrical and electronic applications. Unclad, the material can be used for mock-up boards, gaskets and other insulation purposes.

Polyethylene Extrusions

Two new polyethylene materials are available as extrusions from *Anchor Plastics Co., Inc.*, 36-36 36th St., Long Island City 6, N. Y. They are: 1) the new linear, or low pressure, polyethylene (Super-Dylan), and 2) a new crack-resistant polyethylene formulation, which is a modification of a standard type of polyethylene.

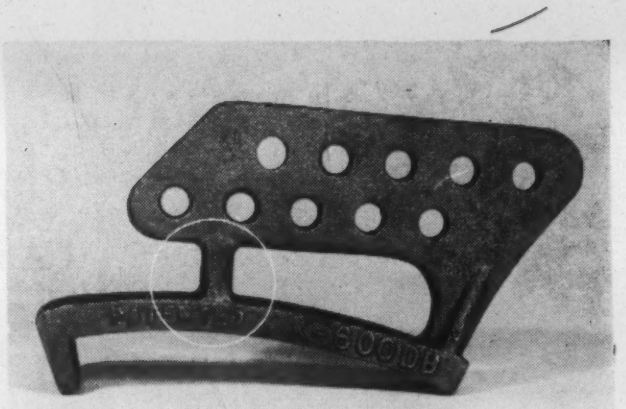
Linear polyethylene

Extrusions of the high tensile, high temperature resistant polyethylene are available in limited quantitites, possibly ranging up to

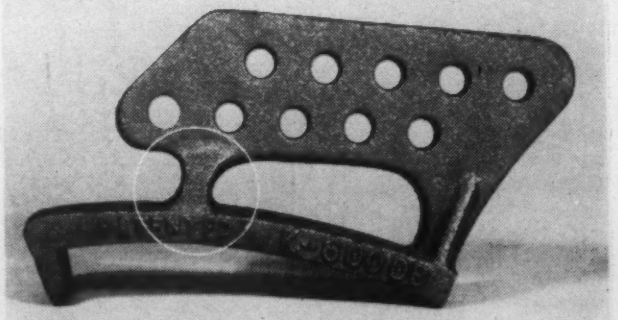
the man from Texas Foundries says . . .

Our engineers increased bracket strength 57% without increasing cost.

A farm implement manufacturer was using a plow sweep bracket of malleable iron. Failures occurred when loads were increased beyond the limits of the original design. Texas Foundries' engineers were called in to help re-design the casting to accommodate the higher loads. (Circled area in upper photo shows where breakage occurred.)



By slightly modifying the original design, strength of casting was increased 57%. Smooth flowing lines of redesigned casting provide uniform stress distribution throughout the part. (See lower photo.)



Your inquiries are invited.

Texas Foundries

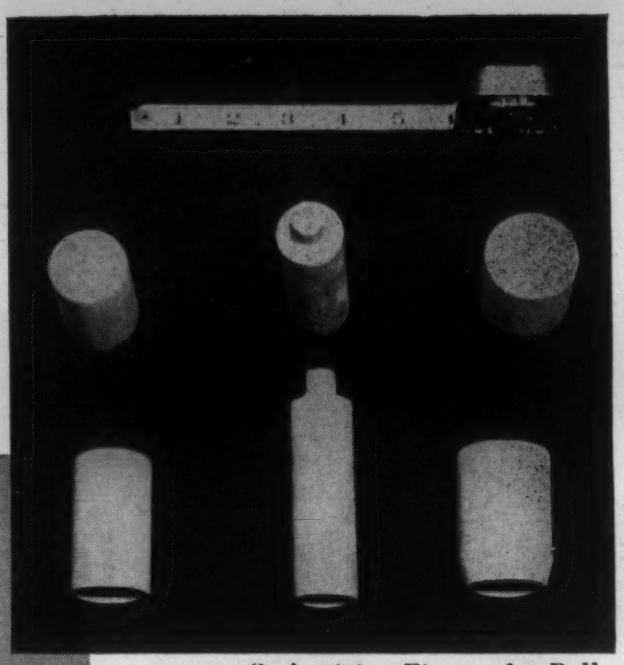
Organized for Service

LUFKIN, TEXAS

For more information, turn to Reader Service Card, Circle No. 413

Small

HIGH ALLOY
CASTINGS

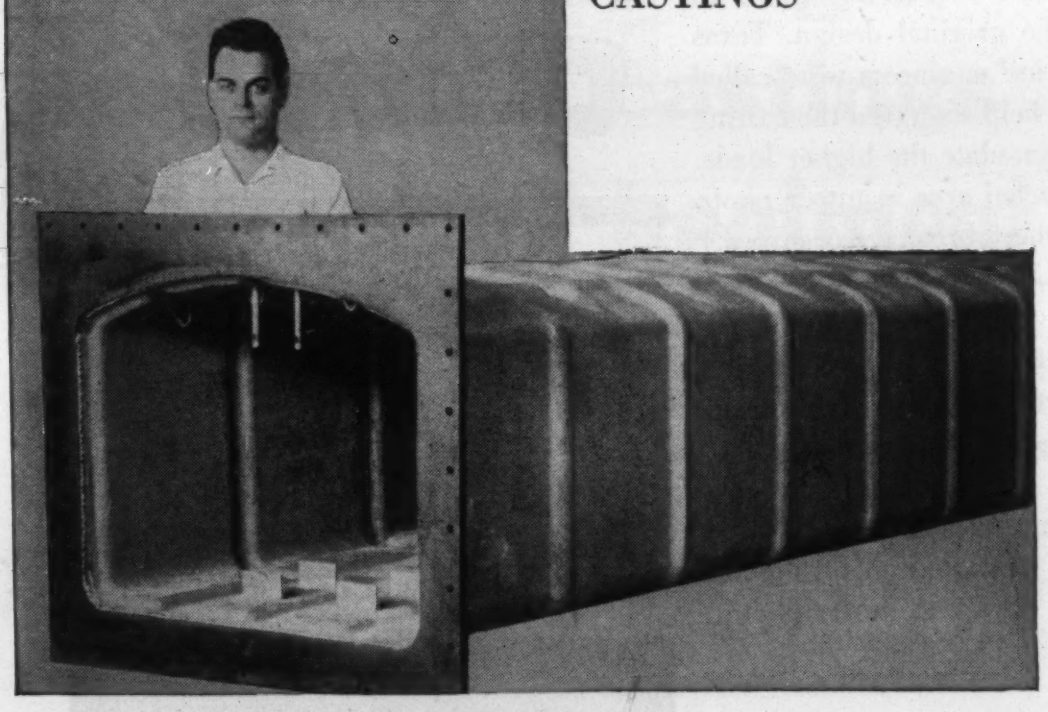


Carburizing Fixture for Ball Bearings 1½" diameter—
Analysis 35% Ni — 15% Cr

DURALOY

Large

HIGH ALLOY
CASTINGS



Muffle for Continuous Strip Annealing
12' 6" long — Analysis 38% Ni — 18% Cr.

LARGE or small DURALOY, can do it! These are just typical examples of the work moving through our foundry. Some of these castings are designed for heat resistance, some for corrosion resistance, some for abrasion resistance; all are cast by experienced foundrymen. All are carefully tested in our up-to-date laboratory.

If you have a high alloy casting problem . . . LARGE or small, we can help you. For more information, send for Bulletin No. 3150-G.

THE DURALOY COMPANY
OFFICE AND PLANT: Scottdale, Pa.
EASTERN OFFICE: 12 East 41st Street, New York 17, N. Y.
DETROIT OFFICE: 23906 Woodward Avenue, Pleasant Ridge, Mich.
CHICAGO OFFICE: 332 South Michigan Avenue

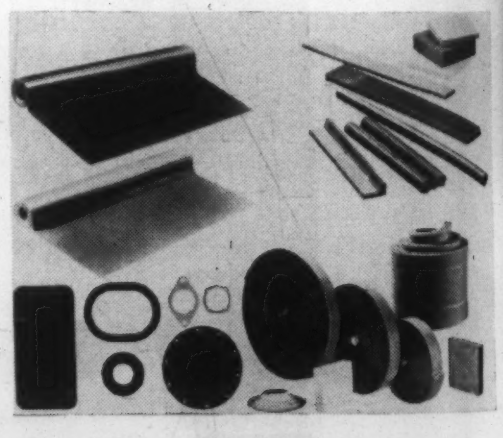
For more information, turn to Reader Service Card, Circle No. 386

OTHER NEW MATERIALS, PRODUCTS

3000 to 5000 lb. Called Super Aeroflex extrusions, they are more rigid than ordinary polyethylene, can withstand higher pressures in tubular form, and will not stress-crack. Due to higher strength and greater rigidity, extrusions can be thinner in cross-section resulting in reductions in cost and weight. According to Anchor, price of the new material in production quantities will be about the same as that of regular polyethylene.

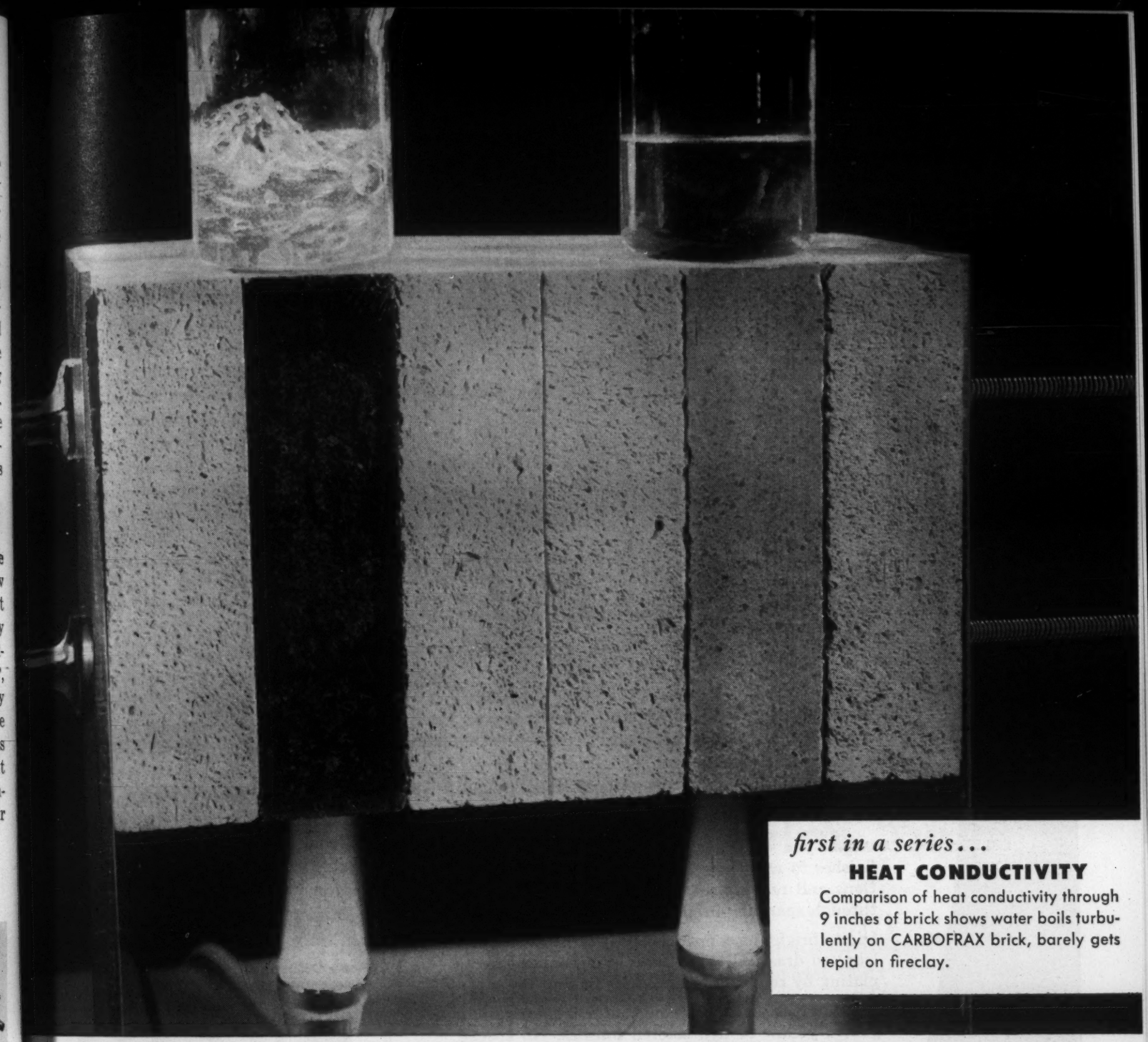
Crack-resistant polyethylene

A new formulatiton of a type of regular polyethylene is now said to provide a crack-resistant material with the same flexibility and other properties as the standard material. Called Aeroflex P, it has already been successfully used in tubular form for flexible shafts, atomizers, soda fountains and aerosol container dip tubes. It is extruded to specification by Anchor in the form of tube, rod or strip as well as other shapes.



Natural and Synthetic Rubber Sheet

A line of pure gum and synthetic rubber sheet packing for a variety of industrial applications has been marketed by *Quality Rubber and Transmission Co.*, Dept. MMN, 2203 W. Chicago Ave., Chicago 22. Stocks include: 1) red and black sheets in nylon and plate finishes for hot and cold water, general hydraulic conditions, and steam and gas pressures; 2) chute lining and skirt board rubber, with all rubber and fabric back, which resists cutting



first in a series...

HEAT CONDUCTIVITY

Comparison of heat conductivity through 9 inches of brick shows water boils turbulently on CARBOFRAX brick, barely gets tepid on fireclay.

Unusual Properties of Refractory Materials

High heat conductivity — roughly 11 times that of fireclay and about 70% that of chrome-nickel steels — is one of the properties of CARBOFRAX® silicon carbide refractory brick. It is an ideal material for muffles, radiant tubes, retorts and similar structures where you need exceptional resistance to direct flame *plus* the ability to conduct heat efficiently. At 2200°F, thermal conductivity of CARBOFRAX brick is 109BTU/hr., sq. ft. and °F/in. of thickness.

CARBOFRAX refractories typify the many super refractories pioneered by Carborundum. Each has a wide range of properties. One, for example, is formed into precision parts that look like cast iron yet resist over 3000°F. Another, a new ceramic fiber, filters and insulates at temperatures no existing mineral or glass fiber can take.

Carborundum's new magazine "Refractories" pinpoints many practical applications for these unusual products. The forthcoming issue carries a feature article on "Heat Conductivity". Send for your copy today.

CARBORUNDUM

Registered Trade Mark

VALUABLE INFORMATION FOR USERS OF:

REFRACTORIES • CASTABLE CEMENTS • POROUS PLATES AND TUBES

CATALYST SUPPORTS • OXIDE, BORIDE, NITRIDE AND CARBIDE

HIGH-TEMPERATURE MATERIALS • CERAMIC FIBER

all in the new magazine "Refractories"

—————MAIL THIS COUPON TODAY—————

Dept. R16, Refractories Division
The Carborundum Co., Perth Amboy, N. J.

Please send me the forthcoming issue of "Refractories".

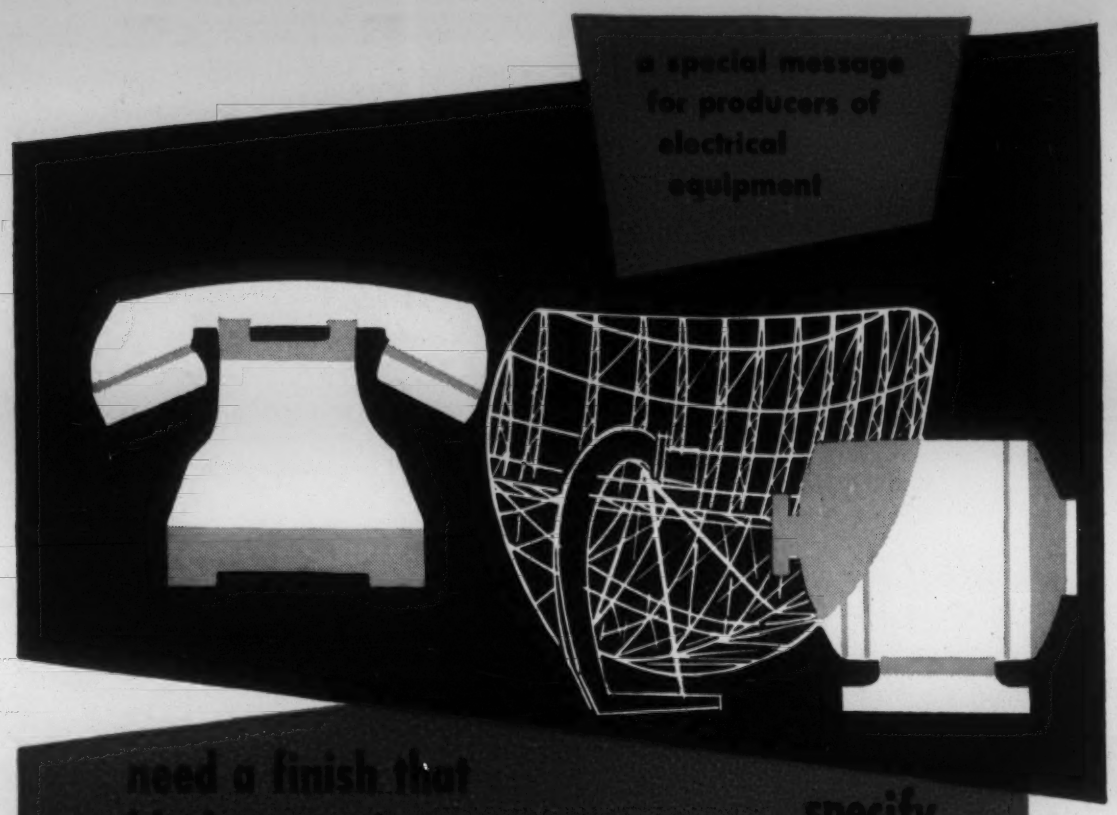
Name_____ **Title**_____

Company_____

Street_____

City_____ **Zone**____ **State**_____

For more information, Circle No. 328



need a finish that blocks corrosion, maintains conductivity?

specify IRIDITE®

Here's peak corrosion protection combined with conductivity, weldability and solderability. Here's a finish that holds paint firmly, prevents underfilm corrosion. Here's a line of attractive final finishes to add quality and sales-appeal. Here's Iridite . . . and here's how you can use it:

ON ZINC AND CADMIUM you can get highly corrosion resistant finishes to meet any military or civilian specifications and ranging in appearance from olive drab through sparkling bright and dyed colors.

ON COPPER . . . Iridite brightens copper, keeps it tarnish-free; also lets you drastically cut the cost of copper-chrome plating by reducing the need for buffing.

ON ALUMINUM Iridite gives you a choice of natural aluminum, a golden yellow or dye colored finishes. No special racks. No high temperatures. No long immersion. Process in bulk.

ON MAGNESIUM Iridite provides a highly protective film in deepening shades of brown. No boiling, elaborate cleaning or long immersions.

AND IRIDITE IS EASY TO APPLY. Goes on at room temperature by dip, brush or spray. No electrolysis. No special equipment. No exhausts. No specially trained operators. Single dip for basic coatings. Double dip for dye colors. The protective Iridite coating is not a superimposed film, cannot flake, chip or peel.

WANT TO KNOW MORE? We'll gladly treat samples or send you complete data. Write direct or call in your Iridite Field Engineer. He's listed under "Plating Supplies" in your classified telephone book.

Iridite is approved under government specifications

ALLIED RESEARCH PRODUCTS
INCORPORATED
4004-06 E. MONUMENT STREET • BALTIMORE 5, MD
Manufacturers of Iridite Finishes for Corrosion Protection and Paint Systems on Non-Ferrous Metals, ARP Plating Chemicals.
WEST COAST LICENSEE: L. H. Butcher Co.

For more information, turn to Reader Service Card, Circle No. 445

OTHER NEW MATERIALS, PRODUCTS

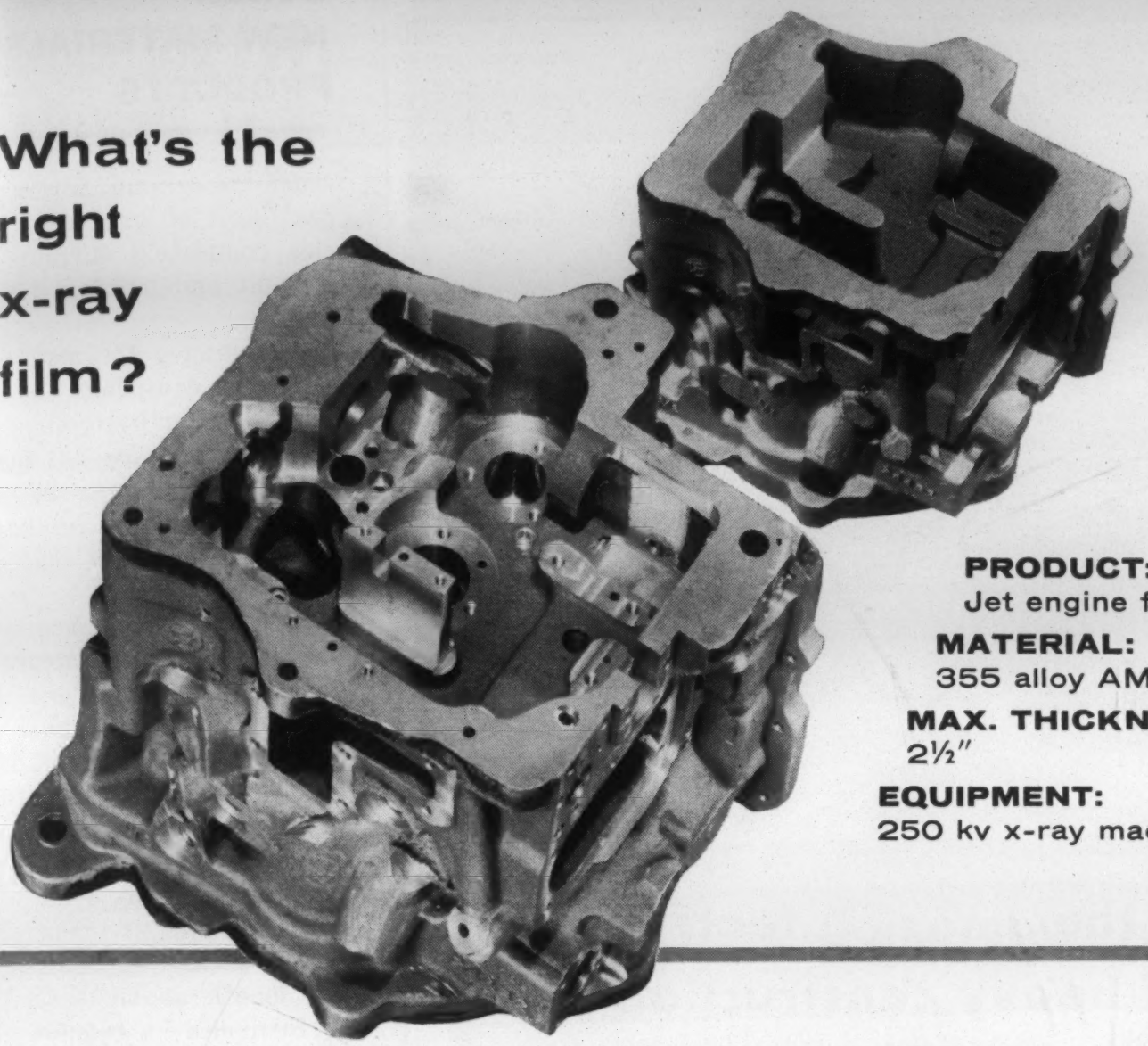
and abrasion in such uses as linings for tanks, chutes, troughs and as skirt boards on conveyors; 3) amber, pure gum, floating stock for vibration dampers, flexible joints, soft cushions, bumpers and soft sealing gaskets in hydraulic and general chemical service; 4) commercial grade black and black neoprene for oil- and solvent-resistant seals and gaskets on hatches, doors, joints, pumps, tanks or pipelines; 5) black diaphragm sheet for blankets, curtains, cut gaskets, reducing valves and regulators to resist swelling in petro-chemical, acid, alkali and comparable service; and 6) sponge rubber sheet stock which can be furnished in soft, medium and firm densities with special colors to order. These latter sheets can also be supplied with dryback cement or pressure-sensitive adhesive backing.

Sheet stock comes in standard 36- and 42-in. rolls in thicknesses from 1/16 in. Specially designed shapes are available to specification.

Crushable Ceramic Tubing for Insulation

Crushable ceramic tubing, AlSiMag 555, intended as insulation for enclosed heating elements has been developed by *American Lava Corp.*, Cherokee Blvd. & Mfrs. Rd., Chattanooga 5, Tenn. Heating elements are inserted into holes in the tube, which is then inserted into the outer metal sheath of the heating element. Subsequent swaging operations

What's the right x-ray film?



PRODUCT:
Jet engine fuel pump

MATERIAL:
355 alloy AMS 4214

MAX. THICKNESS:
2½″

EQUIPMENT:
250 kv x-ray machine

✓ Kodak Industrial X-ray Film, Type A

Machining costs 8 times the price of this rough casting. And the alloy used is prone to gas and shrinkage which can make the part a total loss. So radiography is used to insure that only sound castings are machined.

In making these exposures the radiographer used 165 kv, 80 secs at 48 in., and Kodak Industrial X-ray Film, Type A.

This film is first choice for routine examination of light alloys as it provides short exposure time with suitably low kilovoltage technics.

RADIOGRAPHY...
another important example of Photography at Work

THERE'S A RIGHT FILM FOR EVERY PROBLEM

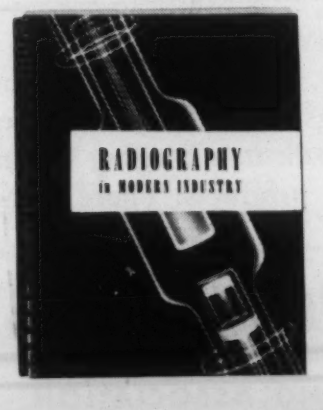
Whatever your radiographic problem, you'll find the best means of solving it in one of Kodak's four types of industrial x-ray film. This choice provides the means to check castings and welds efficiently, offers optimum results with varying alloys, thicknesses, and radiographic sources.

Type A—has high contrast and fine graininess with adequate speed for study of light alloys at low voltage—heavy parts at intermediate and high voltages. Used direct or with lead-foil screens.

Type F—provides the highest available speed and contrast when exposed with calcium tungstate intensifying screens. Has wide latitude with either x-rays or gamma rays when exposed directly or with lead screens.

Type K—has medium contrast with high speed. Designed for gamma ray and x-ray work where highest possible speed is needed with available kilovoltage, without use of calcium tungstate screens.

Type M—provides maximum radiographic sensitivity with direct exposure or lead-foil screens. It has extra-fine grain and, though speed is less than Type A, it is adequate for light alloys at average kilovoltages and preferred for much million- and multimillion-volt work.



RADIOGRAPHY IN MODERN INDUSTRY

A wealth of invaluable data on radiographic principles, practice, and technics. Profusely illustrated with photographs, colorful drawings, diagrams, and charts. Get a copy from your local x-ray dealer—price $3.

EASTMAN KODAK COMPANY
X-ray Division
Rochester 4, N.Y.

Kodak
TRADE MARK

For more information, turn to Reader Service Card, Circle No. 448

the amazing feats of heavy construction made possible by forgings

America's $15 billion a year heavy construction industry is performing stupendous feats. For example, it can load earth-movers like that pictured at rates above 1,000 lbs. per second, then wheel away the loaded rig weighing more than 80,000 lbs. at speeds up to 25 M.P.H.

To permit such performance critical parts of tractors, buggies, shovels, draglines, dozers and other equipment are closed-die forgings. Forged parts can be trusted to do the job.

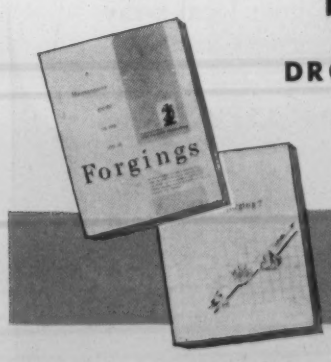
Forgings also help makers of this equipment to produce economically, as they do all manufacturers fabricating in metal. To quote case histories: "saved 26% in machining time"; "cut materials cost 20%"; "saved 50% in weight"; "reduced rejects 70%".

How about your product, your process? Get the latest information about what forgings can do for you. Write for the booklets described below, and talk to a Forging Engineer about the use of forgings in your products. There is no obligation.

closed-die forgings for metal you can trust

DROP FORGING ASSOCIATION

419 S. Walnut St. • Lansing, Michigan



Symbolic emblem of the Drop Forging Association

Attach this advertisement signature to your letterhead and mail to Drop Forging Association to receive booklet "What is a Forging?" ☐ or "Management Guide to Use of Forgings". ☐ Check title or titles desired.

For more information, turn to Reader Service Card, Circle No. 336

OTHER NEW MATERIALS, PRODUCTS

crush the ceramic, forming a compact layer of small ceramic particles completely surrounding the element and holding it firmly in place.

Advantages for manufacturers of such equipment as electric ranges, water heaters and immersion heaters are 1) speeds assembly operations; 2) prevents skips or gaps in insulation; 3) gives close control over heating unit wire; and 4) maintains proper, uniform separation of electrodes. Also, according to American Lava, cost of the tubing results in a higher quality product at lower cost. The tubing has been successfuflly used with small electrodes without causing damage during swaging. Lengths of about 3 in. with one or more holes are generally preferred, though almost any diameter, length or cross section can be furnished on request.

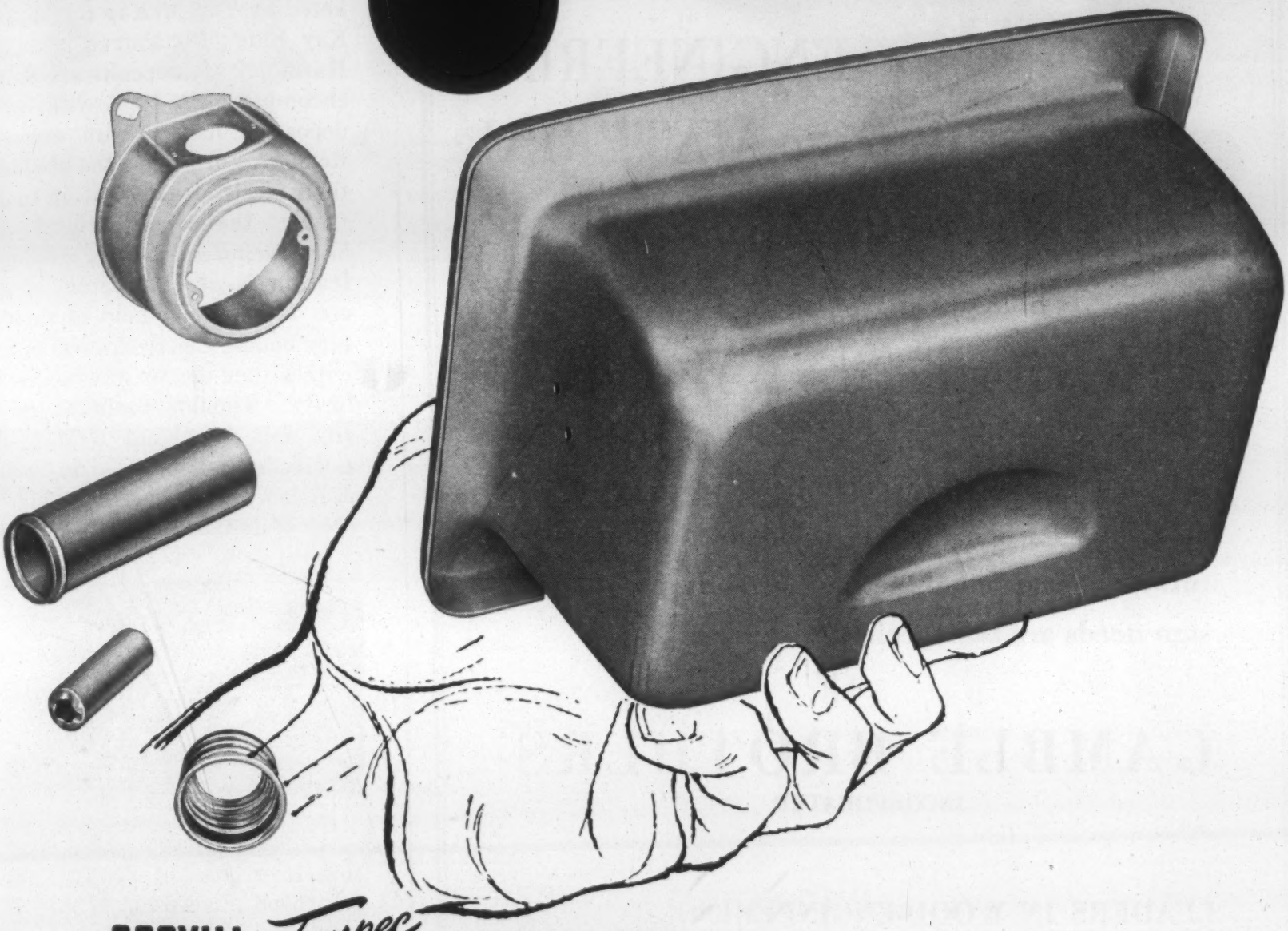
Welding and Soldering Materials

New welding and soldering materials developed recently include three iron powder electrodes: a low hydrogen hard-facing electrode, an all-position electrode, and a maintenance and repair electrode; and two soldering alloys: a silver solder for joining dissimilar metals, and a fluxless solder for joining aluminum.

Iron powder electrodes

Low hydrogen hard-facing rod —An iron powder, low hydrogen

You can **sell** the difference



SCOVILL *Truspec* ALUMINUM...

Is an exclusive development that exemplifies what we mean when we stress the salable difference in Scovill Mill Products.

Here is aluminum that sets a new standard of uniformity in meeting close specifications . . . in precision control of directional properties, temper and grain size . . . in close dimensional limits and fine finish . . . features that mark a distinct difference in commercial wrought aluminum sheet alloys.

The above photograph of typical parts demonstrates the fine fabricating qualities of Truspec . . . that make it possible for you to control "earing" and "orange peel" effect to a far greater degree than has been possible in the past.

As a result, products made from Truspec Aluminum show superior quality and finish, with fewer rejects at maximum production . . . differences any fabricator can SELL in today's market.

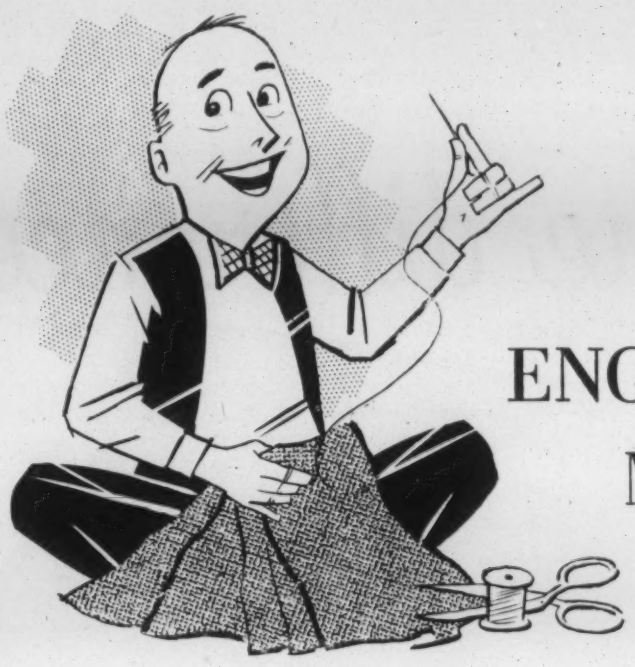
Scovill Manufacturing Company, Mill Products Division, 99 Mill Street, Waterbury 20, Connecticut. Phone PLaza 4-1171.

SCOVILL MILL PRODUCTS

BRASS • BRONZE • NICKEL SILVER • ALUMINUM

17SC55

For more information, turn to Reader Service Card, Circle No. 372



THE TAILOR-MADE ENGINEERING MATERIAL:

GAM-EN-WOOD®

Special shapes—exceptional sizes—laminates of selected woods, or of wood and other structural materials combined to precisely fit your design needs are the specialties of

GAMBLE BROTHERS
INCORPORATED

LEADERS IN WOOD-ENGINEERING FOR MORE THAN 50 YEARS

Discuss your needs—or problems—with our design and development engineers. No obligation, of course. Write or phone today.

GAMBLE BROTHERS
Incorporated

4603 Almond Avenue
Louisville 9, Kentucky

GAMBLE BROTHERS GB GUARANTEED BOND

For more information, turn to Reader Service Card, Circle No. 393

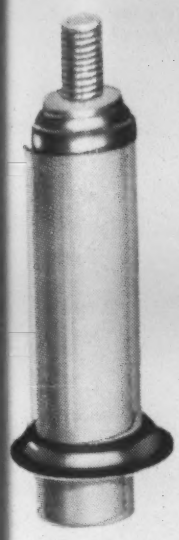
OTHER NEW MATERIALS, PRODUCTS

hard-surfacing electrode, said to combine speed of application with metal soundness and crack resistance of deposits has been marketed by *The McKay Co.*, 307 McKay Bldg., Pittsburgh 22. Called Hardalloy 48, deposits are of high chromium-iron type with an as-deposited hardness in excess of Rc 55. According to the producers, their electrodes deposit up to 50% faster than conventional type hard-facing electrodes, and penetration is at a minmum consistent with development of satisfactory bonds. Electrodes can be used with either a.c. or d.c. reverse polarity. Though designed primarily for downhand welding, the electrodes can be used in vertical position. They are available in sizes of 1/8, 5/32, and 3/16 in. dia.

All-position rod — An all-position iron powder electrode called Improved Fleetweld 47 has been marketed by *The Lincoln Electric Co.*, 22801 St. Clair Ave., Cleveland 17, Ohio. It is intended as a universal type electrode which deposits at higher speeds than conventional electrodes. According to Lincoln, it welds mild steel rapidly with either a.c. or d.c. current. The powdered iron is said to raise welding speeds 10 to 30% higher than that obtainable with conventional E-6013 electrodes. Bead appearance is smooth with minimum spatter and the electrodes can be operated with either drag or short arc technique. Electrode conforms to AWS class E-6013 and has been approved by the American Bureau of Shipping. It is available in sizes ranging from 1/8 to 5/16 in. dia.

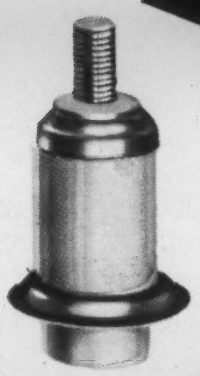
Maintenance and repair rod— An iron powder electrode particu-

ALSIMAG®
HIGH TEMPERATURE HERMETIC TERMINALS
INDIVIDUALLY LEAK TESTED

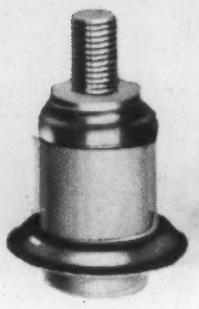


AlSiMag
No. Y-35255

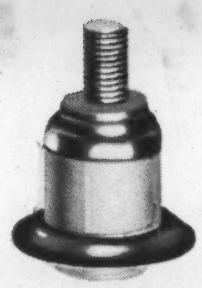
AlSiMag
Y-35254



AlSiMag
Y-35253

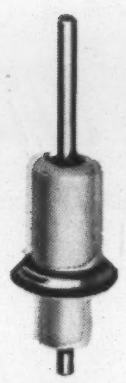


AlSiMag
Y-35252



AlSiMag
Y-35251

AlSiMag
Y-33755

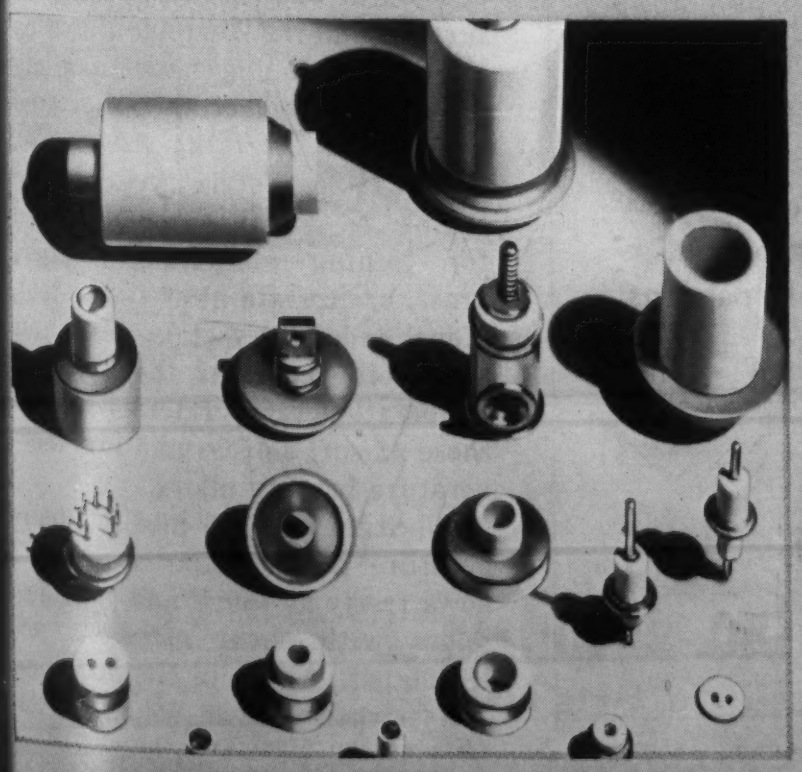


AlSiMag
Y-31490

STRONGER!
Alumina ceramics with higher tensile and impact strengths. Permanent bonding. New glaze with superior surface resistivity. Rugged. Greater resistance to wear, chipping and breakage. Exceed MIL-T-27A torque requirements.

HIGHER TEMPERATURES!
New, superior metalizing techniques. Pace-setting AlSiMag Alumina ceramics. Greatly extended operating temperature range. Readily attached with hard solder. Permit designing to higher temperatures.

GREATER THERMAL SHOCK RESISTANCE:
Retain their excellent electrical and mechanical characteristics and deliver outstanding performance throughout their wider operating temperature range.



CUSTOM ITEMS
in High Temperature Alumina Ceramics with High Temperature Metalizing also available, produced by the same highly skilled techniques. For special applications, a wide choice is offered in metals and ceramics in appropriate design configurations. Metalized parts for low temperature applications can also be supplied. Send blueprint or sketch for complete details.

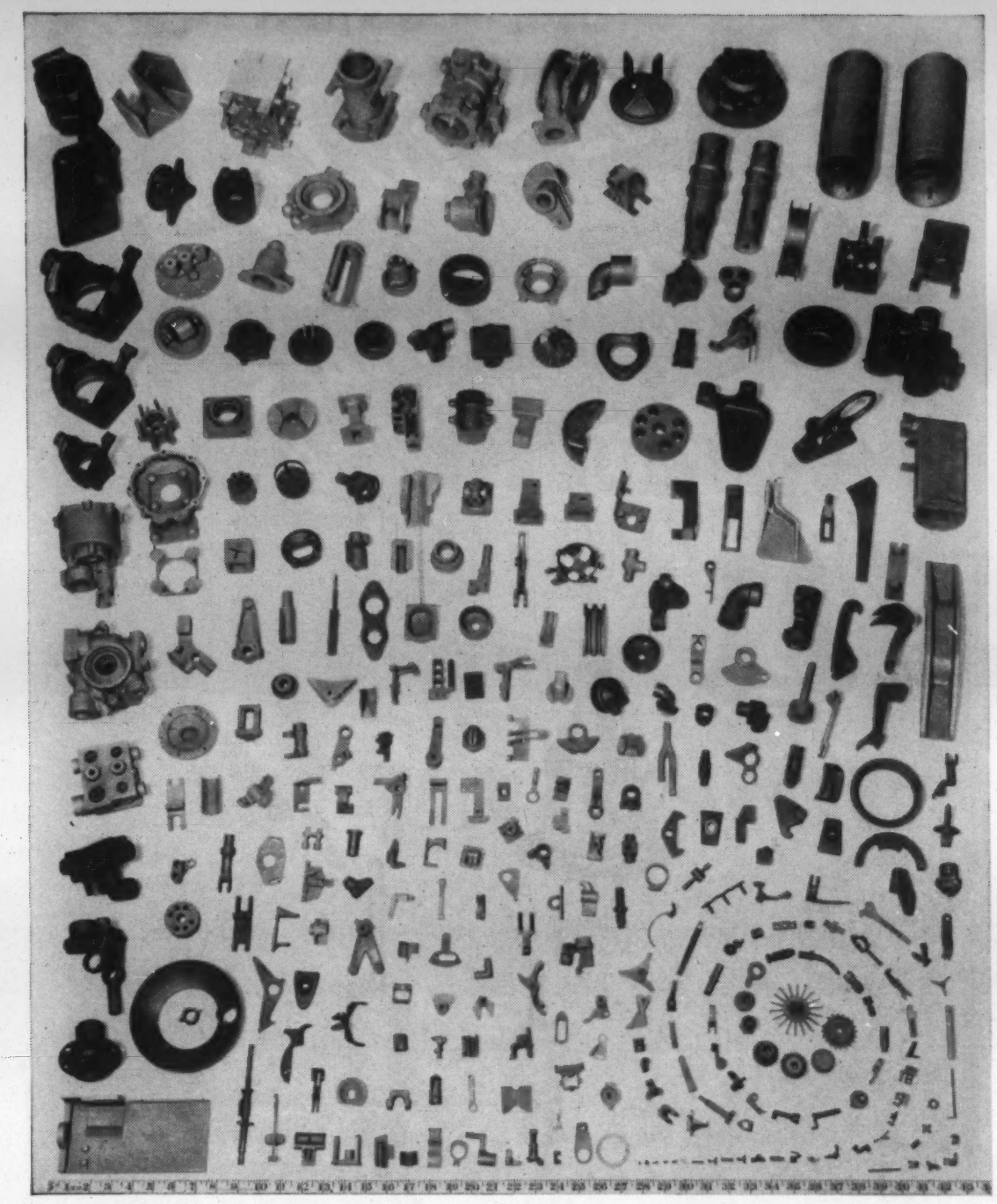
WRITE FOR FREE BULLETIN FULLY DESCRIBING STANDARD PARTS SHOWN ABOVE

AMERICAN LAVA CORPORATION

54TH YEAR OF CERAMIC LEADERSHIP

CHATTANOOGA 5, TENNESSEE
A Subsidiary of
Minnesota Mining and Manufacturing Company

Branch offices in these cities (see your local telephone directory): Cambridge, Mass. • Chicago, Ill. • Cleveland, Ohio • Dallas-Houston, Texas • Indianapolis, Ind. • Los Angeles, Calif. • Newark, N. J. • Philadelphia, Pa. • St. Louis, Mo. • South San Francisco, Calif. • Syracuse, N. Y. • Tulsa. Okla. **Canada:** Irvington Varnish & Insulator Div., Minnesota Mining & Mfg. of Canada, Ltd., P. O. Box 757, London, Ontario. **All other export:** Minnesota Mining & Mfg. Co., International Division, 99 Park Ave., New York, N. Y.



Investment castings

¼ ounce to 30 pounds . . . up to 12 inches in length . . . 160 ferrous and nonferrous alloys

Precision Metalsmiths makes them all—a million pieces for your production or a few at a time, as you develop a product. Pictured above are some of the investment castings we're making regularly.

Cast to close tolerances and accurate in details, such parts require surprisingly little finishing. Expensive pre-assembly machining is avoided, since complicated parts are produced as single units. We do the assembling with expendable patterns.

Send for the free book, "Pour Yourself an Assembly", describing this time-saving method. Precision Metalsmiths, Inc., 1077 East 200th Street, Cleveland 17, Ohio.

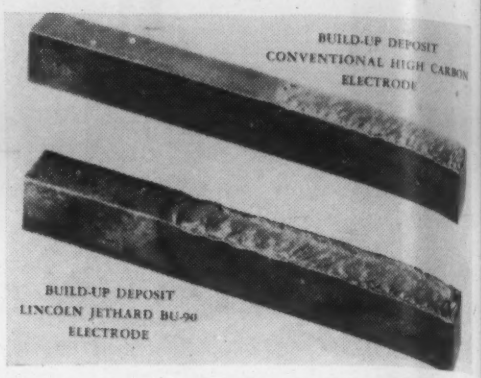
pour yourself an assembly with

PRECISION METALSMITHS, Inc.

Investment Castings

For more information, turn to Reader Service Card, Circle No. 370

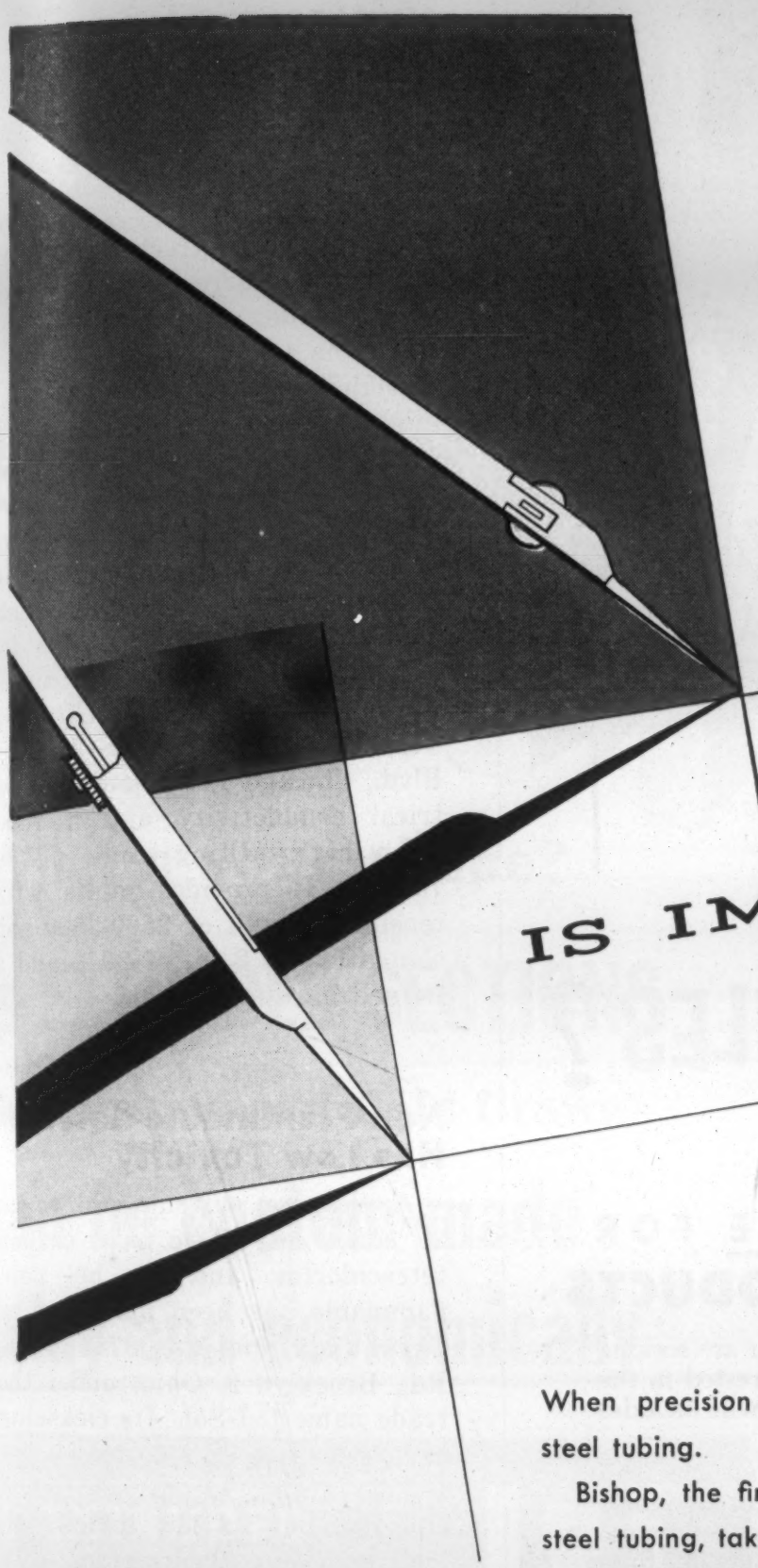
OTHER NEW MATERIALS, PRODUCTS



larly designed for use in maintenance and repair welding has also been marked by *Lincoln Electric Co.* Called Jet-Hard BU-90, the electrode is said to produce a medium carbon, medium alloy deposit for building up worn parts with a dense, moderately hard, machinable surface which will resist shock and abrasion. According to Lincoln, the new rod deposits at speeds which result in a 35 to 45% increase in amount of metal deposited per minute, compared with conventional build-up electrodes. Chromium carbide in the deposit provides abrasion resistance while chromium and manganese provide impact resistance and toughness. Hardness ranges from Rc 27 to 40. Hardness can be increased by water quenching deposit from 1600 F. It operates either on a.c. or d.c. electrode negative and is available in diameters of 5/32, 3/16 and 1/4 in.

Silver alloys for dissimilar metals—Two silver alloys have been developed for joining dissimilar ferrous and non-ferrous alloys by any heating method generally applicable for soldering. Marketed by *All-State Welding Alloys Co., Inc.*, 249-55 Ferris Ave., White Plains, N. Y., they are designed for joining aluminum, copper, brass, bronze, stainless steel, steel, Monel and other metals. Melt and flow points are in the medium temperature range falling between those of soft solders and low temperature brazing alloys.

All-State No. 105 medium temperature solder melts at 675 F, flows freely at 750 F and provides joints with shear strengths of 18,000 psi. All-State No. 107 general purpose silver solder melts



Precision

IS IMPORTANT

Specify Bishop Stainless Steel Tubing (.008" to 1" O.D.)

When precision is important, specify Bishop small diameter stainless steel tubing.

Bishop, the first American company to draw small diameter stainless steel tubing, takes pride in its precise control of all dimensional tolerances. This dimensional precision is made possible by continual inspection, both mechanical and visual, of all operations.

You buy Stainless Steel Tubing for its extra qualities. Get the added advantages of precision craftsmanship and experience by specifying Bishop.

Catalog on request.

Platinum and Platinum group metals
Spinnerettes
Medical Products
Small Diameter Stainless Steel Tubing
Fabricated Tubular Parts

The next time you need precision fabricated tubular parts, investigate Bishop's "under one roof" drawing and fabricating facilities . . . you'll save time and money.

J. BISHOP & CO. PLATINUM WORKS

Stainless Steel Division, Malvern, Pennsylvania

For more information, turn to Reader Service Card, Circle No. 382

ARE WE IN YOUR FILES?

AS A DEPENDABLE SOURCE FOR MAGNESIUM PARTS AND PRODUCTS

Whether you plan the development of a new product, or are seeking ways to further improve existing ones, you will be interested in the many new avenues which are open to the design engineer who includes magnesium in his basic planning.

Magline Inc.—one of America's leaders in magnesium—has prepared a descriptive new bulletin, expressly outlining for designers and engineers, the company's services as a reliable, experienced source for magnesium castings, fabrication and complete production. Specialists in magnesium exclusively, Magline's background and experience will serve you well in three important ways: (1) Objectively searching out ways to improve your product through the application of magnesium; (2) Assisting in the design and development phases; (3) Producing the required parts and components in any quantity, to your exact specifications. May we send you a copy of Bulletin No. 50.

MagLine

fabrication facilities for

- Forming
- Machining
- Welding
- Stamping
- Spinning
- Deep Drawing
- Polishing
- Finishing
- Stress Relieving
- Assembly
- Impact Extruding

foundry facilities for

- Sand Castings
- Die Castings
- Permanent Molds

Design and Engineering Services Available

WRITE TODAY FOR BULLETIN NO. 50. MAGLINE, INC., BOX 141, PINCONNING, MICHIGAN.
CANADIAN FACTORY: MAGLINE OF CANADA, LIMITED, RENFREW, ONTARIO.

For more information, turn to Reader Service Card, Circle No. 397

OTHER NEW MATERIALS, PRODUCTS

at 450 F, flows freely at 600 F, has good corrosion resistance and provides joints with shear strengths up to 20,000 psi.

Solder for aluminum—An aluminum solder, which requires no flux, has been marketed for joining aluminum to copper, brass and other nonferrous metals. Containing no aluminum, cadmium, lead or antimony, the solder is resistant to corrosion and retains its original bright color after application. Developed by *Ultralloy Corp.*, Rm. 1018, 53 W. Jackson Blvd., Chicago 4, it has high electrical conductivity and a relatively high melting point of 700-750 F. It provides joints with tensile strength of 2500-3500 psi, elongation in 2 in. of 20% and a Brinell hardness of 23.

Non-Flammable Solvent Has Low Toxicity

A cleaning solvent said to be 20 times less toxic than carbon tetrachloride and to be nonflammable has been marketed by *Chem Industrial Co.*, 3784 Ridge Rd., Brooklyn 9, Ohio, under the trade name C-I-Sol. Its cleansing properties are said to closely resemble those of carbon tetrachloride, but its low toxicity allows heavier concentrations to be used without danger to workmen.

C-I-Sol is recommended for removing grease, wax, oil and tars from metal products. Though it is not suitable for vapor degreasing, it is adaptable to cold cleaning, dip cleaning and bucket cleaning.

Low Temperature Nickel Base Brazing Alloy

Low brazing temperature, high flow and wetting properties, thin to moderate fillet formation and no erosion during brazing are features claimed for a new nickel-phosphorous brazing alloy called

What's your shape?

J&L's EXTRUDED SECTIONS

(Hot Extruded and Cold Drawn)

can be custom-made quickly and economically

Now your complex sections can be *custom-made* at J&L's new Hot Extrusion Plant. On J&L's new equipment, they can be preformed to the predominating cross section of the part you wish to produce.

The range of sections that can be custom-made for you is almost unlimited. Quantities are extremely flexible. Production of single extrusions, where necessary, can be arranged.

In addition, J&L's Extruded Sections possess the physical benefits and accurate tolerances derived from cold drawing. And, you can obtain them in a wide range of analyses.

Send your inquiry today!

J&L EXTRUDED SECTIONS
lp speed production
duce over-all costs

J&L STEEL

Jones & Laughlin
STEEL CORPORATION — *Pittsburgh*

With J&L's Extruded Sections you can:

1. Eliminate time and costs in machining operations.
2. Eliminate time and costs in finishing operations.
3. Reduce scrap losses practically to the zero point.
4. Eliminate the cost of castings and forgings of intricate sections requiring considerable machining.

For more information, turn to Reader Service Card, Circle No. 458

USE THIS HANDY COUPON

Jones & Laughlin Steel Corporation
3 Gateway Center, Dept. 474, Pittsburgh 30, Pa.

I am interested in knowing what your Extruded Sections can do for me.

NAME_____

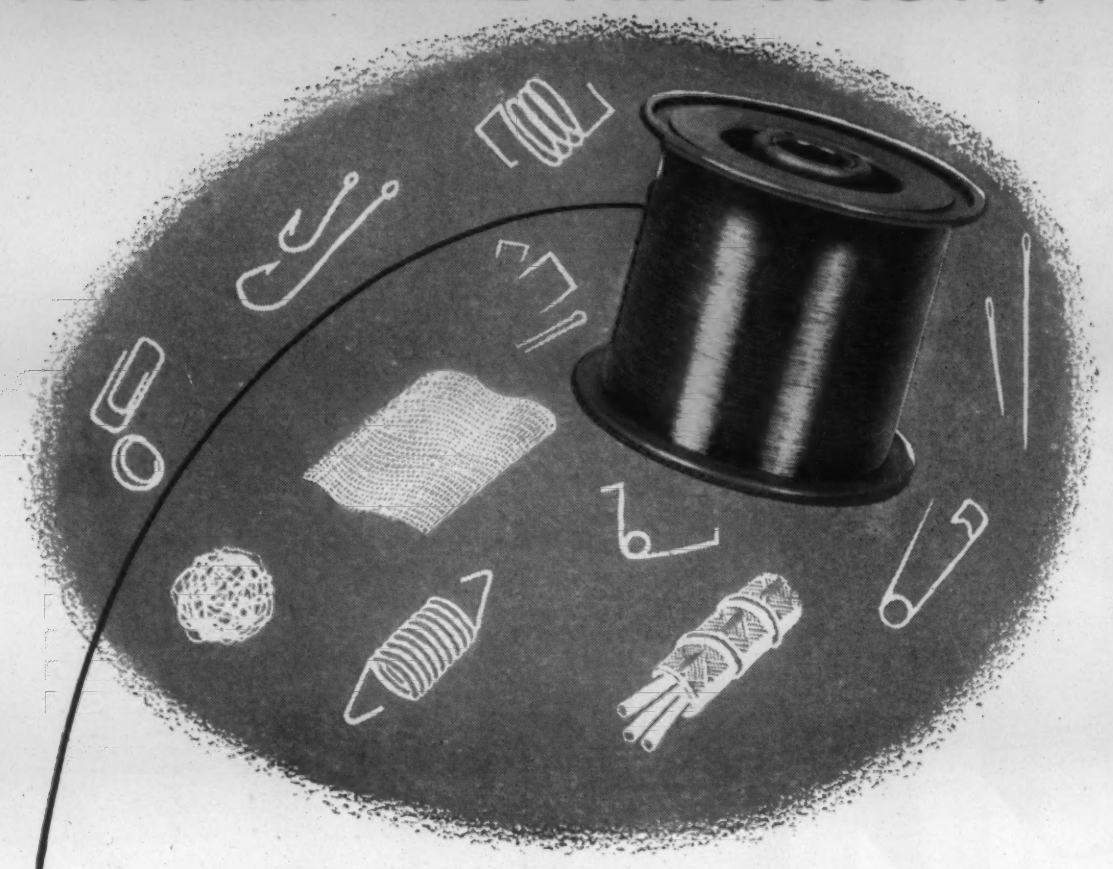
TITLE_____

COMPANY_____

STREET_____

CITY_____ ZONE_____ STATE_____

FOR FINE WIRE PRODUCTS . . .



Almet Stainless Steels

MEET MORE REQUIREMENTS

THAN OTHER ENGINEERING MATERIALS

Does your Fine Wire application call for resistance to heat? . . . to corrosion? Does it require good fatigue properties . . . excellent weaving or other forming characteristics? There's a good chance you will find the material you need among the more than 20 grades of stainless steel we fabricate into high quality Fine Wire. No other family of metals has the combination of properties common to the stainless steels.

Learn more about the interesting properties and applications of our stainless steel Fine Wire, as well as our stainless Rod and Strip . . . send today for a copy of our new 40 page Stainless Steel Design Handbook.

ALLOY METAL WIRE DIVISION

A DIVISION OF HKP H. K. PORTER COMPANY, INC.

Prospect Park, Pennsylvania

For more information, turn to Reader Service Card, Circle No. 366

OTHER NEW MATERIALS, PRODUCTS

Nicrobraz No. 10. Developed by *Wall Colmonoy Corp.*, 19345 John R St., Detroit 3, the alloy is recommended for low temperature joining of stainless steels, nickel-base alloys and cobalt base alloys, as well as low alloy steels, carbon steels, copper, and other base metals with melting points above 1900 F. It is intended for applications involving service temperatures up to 1500 F.

The material is available in the form of a powder which can be brushed, cold sprayed or hot sprayed after mixing with suitable quantities of Nicrobraz Cement. The material is self-fluxing and will flow where the atmosphere may be marginal. It can be used in any controlled atmosphere as long as the base metal does not oxidize and remains bright and clean.

Recommended brazing temperature is 1850 F, and the alloy's useful flow temperature is around 1625 F. Compression shear strength of joints is said to be 45,000 psi or higher.

Polyvinyl Acetate Adhesive

A fast-setting polyvinyl acetate adhesive which requires no mixing or heating has been marketed by *Midcontinent Adhesive Co.*, Grove City, Ohio. Called Roltite white glue, the adhesive obtains an initial set in 20 to 30 min with soft wood, and reaches its maximum strength in 24 to 72 hr.

The cured bond is immune to attack by mold and bacteria and has high moisture resistance. It is said to be non-flammable, nontoxic, and unaffected by greases, oils, mild alkalis, acids and petroleum solvents. The glue can be used to bond wood, leather, cloth, paper, composition board, plastics, plywood and linoleum. Tests on hard maple samples glued with mild pressure show average shear strength values of about 2900 psi with 60% wood failure.

TRUFLEX® Thermostat Metal Coils Over ⅓ Mile Long in One Piece Simplify Fabrication and Reduce Costs in Thermal Element Manufacture

The problem . . . to obtain thermostat metal strip in a series of types having sufficiently uniform dimensional control and temperature response to be fabricated into finished parts on automatic machines.

The solution . . . Step 1; the consistent quality of each type of TRUFLEX tested quickly demonstrated that mass production by machine was fully practical for all types.

Step 2; General Plate Division then supplied the required types in long coils 3 feet in diameter with center hole to fit the customer's automatic machine arbors. Each coil is a continuous piece 1800 feet long, by 0.040″ thick and 0.250″ wide.

These coils save the customer many dollars by minimizing idle machine time and eliminating costly waste of material in fabrication.

If your products require temperature control . . . indication or compensation, the accurate performance and uniform high quality of TRUFLEX Thermostat Metals will save you money too.

Here's why! General Plate Division uses advanced production methods, combining the best equipment available with years of manufacturing "know how", to insure positive consistence in thermal and mechanical performance of TRUFLEX Thermostat Metals.

General Plate Division will fabricate parts from TRUFLEX to meet the specific mechanical and electrical performance demands of your particular applications. Or, if you prefer to make your own parts, General Plate Division will supply TRUFLEX Thermostat Metal in strip to meet your specifications.

Write today for your copy of the new TRUFLEX Thermostat Metal Catalog. Engineering assistance available without obligation.

GENERAL PLATE ELECTRICAL CONTACT KIT FOR LABORATORY AND DEVELOPMENT USE

Kit K11 contains a wide assortment of silver rivet contacts; Kit K12 has representative standard button contacts. Also included are metal strips for fabrication of contact parts. These kits are available at nominal cost.

METALS & CONTROLS CORPORATION
GENERAL PLATE DIVISION
61 FOREST STREET, ATTLEBORO, MASS.

You can profit by using General Plate Composite Metals!

For more information, turn to Reader Service Card, Circle No. 440

The Finest Products Made with Aluminum

are made with

REYNOLDS ALUMINUM

© REYNOLDS METALS COMPANY

THE KEY TO FINER PRODUCTS MADE WITH ALUMINUM is often found in this library of handbooks. They're filled with important, useful information on aluminum design and fabrication. Whether your job is management, design or production, these books can be vital to you. Single copies of any or all are yours free when requested on your business letterhead.

ALUMINUM DATA BOOK—160 tables give complete physical, chemical and mechanical properties; availability data, tolerances, definitions, fabrication information . . . 220 pages.

DESIGNING WITH ALUMINUM EXTRUSIONS—Explains the basic principles for using extruded aluminum shapes most effectively . . . 138 pages.

ALUMINUM STRUCTURAL DESIGN—Shows how to design original structures with aluminum or convert present designs to aluminum . . . 130 pages.

FASTENING METHODS FOR ALUMINUM—Offers information on mechanical joining and fastening methods, and the advantages of each . . . 136 pages,

FINISHES FOR ALUMINUM—Gives basic data on application and uses for electroplated, mechanical, chemical and organic finishes . . . 124 pages.

ALUMINUM FORMING—Presents accepted practices for bending, forming and drawing aluminum . . . 152 pages.

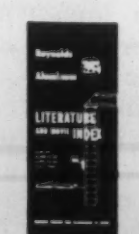
MACHINING ALUMINUM ALLOYS—Covers aluminum machining including automatic screw machining . . . 124 pages.

HEAT TREATING ALUMINUM ALLOYS—Explains the theory and procedures for heat treating aluminum alloys . . . 119 pages.

WELDING ALUMINUM—Gives complete data on the welding, brazing and soldering of aluminum . . . 186 pages.

ALUMINUM POWDERS AND PASTES—Describes types of powders and their uses in paints and coatings, pyrotechnics, processing, metallurgy and other applications . . . 84 pages.

16mm Sound-Color Films Available, too



A COMPLETE INDEX

of all Reynolds Technical Literature and Films on aluminum design and fabrication is also available. Write to Reynolds Metals Company, P. O. Box 1800-HM, Louisville 1, Kentucky.

Instructors in technical schools are also invited to take advantage of these educational aids. Write for details.

REYNOLDS ALUMINUM

For more information, turn to Reader Service Card, Circle No. 474

CONTENTS NOTED

A digest of papers, articles, reports and books of current interest.

This Month:

- *Reinforced plastics in rockets*
- *Modifying vinyl films*
- *Failures in forgings*
- *Powder metal strip*
- *Self-fluxing brazing alloy*

Pros and Cons of Plastics for Rockets

The design of present-day solid propellant rocket cases is a delicate balancing operation in which structural properties, precision machining and cost of production are weighed in search of the most acceptable compromise. The use of glass-reinforced plastics, primarily epoxy, phenolic, polyester and epoxy-phenolic types, was carefully reviewed, and advantages and disadvantages pointed out, in a paper by K. D. Miller, Jr. and S. M. Breslau of the M. W. Kellogg Co. at the 25th Anniversary Annual Meeting of the American Rocket Society last November in Chicago.

Reinforced plastics

Since the glass in glass-reinforced plastics does most of the work, the authors believe the term resin-impregnated glass cloth is more accurate than reinforced plastics. Though the resin does not carry much of the tension loading, it does bind the fibers together and transfers load by shear bonds from fiber to fiber. The resin must bond firmly to the filaments and develop high shear strengths in the bond. It must not peel, it must be rigid to prevent distortion, and it must be resistant to the environment of the rocket component.

Also, since resin and glass are bonded together, and depend on the bond for full strength, they must deflect together under load. Since glass fibers, loaded to capacity stretch between 3 and 4%, the resin must not fail when stretched to this limit. The resin should shrink as little as possible during cure and should be easily handled and non-toxic.

Rocket design

A simplified solid propellant rocket case consists of three basic components: the shell, which is usually cylindrical; a head which closes one end of the cylinder; and a nozzle attached to the other end of the cylinder.

To the mechanical engineer, the rocket case is a pressure vessel. Combustion of the propellant takes place at high pressure, exerting tension forces on the containing walls. The shell is usually the rocket's heaviest component and its chief requirement is usually resistance to simple pressurization stresses. Some axial bending moments occur, but they are usually minor. In most cases, the shell is protected from the rocket flame and may be considered to be cold.

The nozzle and head also receive high pressure loads. The head may be insulated to prevent heating. The nozzle receives severe thermal and erosion attack and must be carefully designed.

Rocket parts are usually loaded briefly and for no more than two or three cycles. After firing, the rocket is often discarded completely. Thus, fatigue resistance is not usually important. General requirements call for resistance to usual military hazards such as weather, spray dirt, fungus, etc. The rocket must not be damaged by long storage and it must operate equally well in the arctic or the tropics.

Advantages of plastics

The advantages of reinforced plastics for rockets are:

1. **Weight reductions** of about 30% over conventional materials are possible because of high strength-to-weight ratios.
2. **Excellent dimensional quality** can be attained in tubes produced on a one-piece mandrel. Since the tube is cured on the machined mandrel, the internal surface of the tube is as true as the surface of the mandrel.
3. **Labor costs are reduced** and machinery required is relatively simple though raw material cost is high. Vessel may be completed in one step, eliminating machining, welding and heat treat operations. Semi-automatic machinery can be installed for filament winding of cylinders.
4. **No critical materials are necessary,** and the resultant product has good insulation properties and erosion resistance.
5. **No shattering** of reinforced pressure vessels occurs on impact.

Disadvantages

Disadvantages of reinforced plastics for rockets, as summarized by the authors are:

1. **Low compression or bearing strength** and low moduli of elasticity are particularly important where droop characteristics are of great concern.
2. **Quality control** is a substantial problem since the materials are heterogeneous.
3. **Most resins deteriorate** at temperatures above 400 F, making the vessel useless for continuous use in that range.
4. **Toxicity of the resin formulations** require sufficient ventilation in work areas.

(More Contents Noted on p. 174)

No Chippage
when you use
Sicon®
SILICONE
HEAT RESISTANT
FINISH

PROVED by over
25,000 TEMCO
Wall Heater
Installations

The upper grille of this handsome TEMCO Gas Wall Heater is finished with 7x7070 Brown SICON Silicone-Base Heat Resistant Finish. The number of louvers on this upper grille presented a chippage problem with vitreous enamel which prompted Temco to turn to SICON. Normal operating temperatures run about 350° F. but the temperature encountered on blocked flue conditions require a heat resistant finish to withstand 500° F...SICON 7x7070 Brown, on 25,000 or more Temco installations, has successfully met field performance requirements without loss of color, gloss or adhesion. Investigate other case histories of SICON—the remarkable finish that has solved over 150 heat resistant finish problems! Write today!

Sicon®
The Original Silicone Base
Heat Resistant Finish
MIDLAND
Industrial Finishes Co.
Waukegan, Illinois
ENAMELS • SYNTHETICS
LACQUERS • VARNISHES

For more information, Circle No. 307

CONTENTS NOTED

Modifying Vinyl Films for Chemical Resistance

Straight vinyl resin films lack adhesion, have poor film formation characteristics, are extremely brittle, and offer poor application characteristics. Therefore, in order to make vinyl films usable, the well known chemical resistance of vinyl resins often must be compromised by the addition of modifying materials. Results of a study by the Northwestern Paint and Varnish Production Club to determine the effect of various modifying agents on the chemical resistance of the usable vinyl films were given in a paper presented by M. C. Hilke at the 33rd Annual Meeting of the Federation of Paint and Varnish Production Clubs last October in New York.

In general, alkyd and oleoresinous varnishes are not good vinyl resin modifiers, phenolic resin tung oil varnish being better than alkyds. Monomeric plasticizers such as tricresyl phosphate and dioctyl phthalate are fair in alkali resistance, poor in acid or hypochlorite, and provide medium resistance to other chemical agents. Paraplex is generally better than the monomeric plasticizers. At high percentage ratios, acrylic polymers are quite good, except in hydrochloric and acetic acids. Chlorinated diphenyl seems to be the best general modifier except for poor resistance to gasoline.

Causes of Failures in Large Turbine Forgings

In the last few years failures of large steel forgings in turbines have focused attention in this field on materials selection and improvement, quality control and inspection. At a joint session of the Power and Metals Engineering Divisions of the American Society of Mechanical Engineers, held during the Diamond Jubilee Annual Meeting of the ASME in Chicago last November, papers covered four of the major failures in detail. The authors revealed the cause of failure and what steps had been taken to insure no future failures in similar equipment.

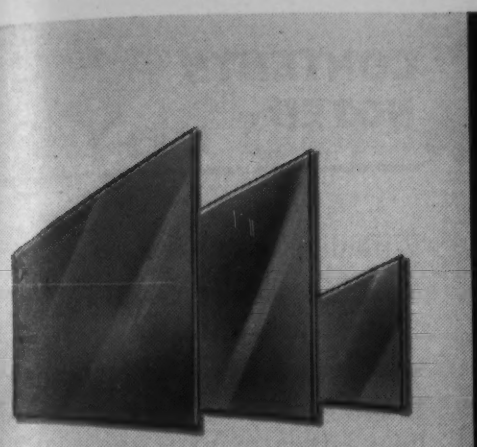
Primarily, the papers pointed up 1) the need for improvements in both techniques of non-destructive testing, such as ultrasonic, and in interpretation of test results; 2) improvements in cleanliness of alloys; 3) elimination of sources of stress concentrations, such as stud holes for repair; and 4) reduction in hydrogen content which could lead to internal embrittlement or flaking.

Cases in point were:

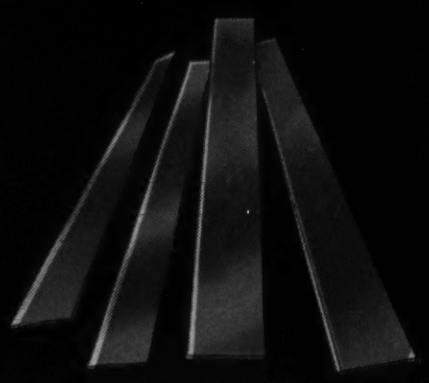
1. The fracture during operation of the 1800-rpm, low-pressure turbine wheel of the No. 1 unit at the Tanners Creek station of the Indiana and Michigan Electric Co. in 1953. The fracture consisted of a radial break from the two holes through which the notch bucket is pinned to the wheel, down to the junction of the wheel and the shaft, thence around the shaft between high-pressure packing for about 60 deg and then outward along a spiral course terminating at the wheel rim about 160 deg from the notch opening.

2. Failure during an overspeed-trip test of the low-pressure spindle of a 165,000-kw cross-compound steam turbine in the Ridgeland Station of the Commonwealth Edison Co. The main spindle burst into four major pieces each consisting of an almost true 90-deg segment.

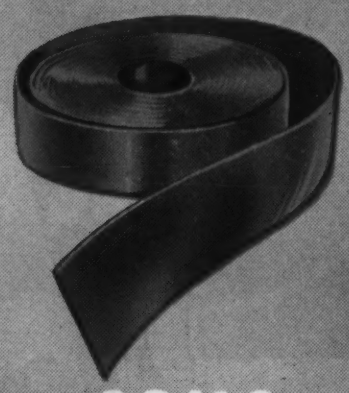
3. Fractures of two 3600-rpm generator rotors while operating at near rated speed. One was for a generator being manufactured for the Arizona Public Service Co.; the other was in a generator at the Cromby Station of the



SHEETS

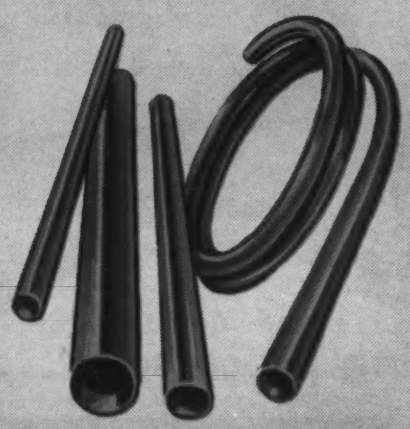


STRIP

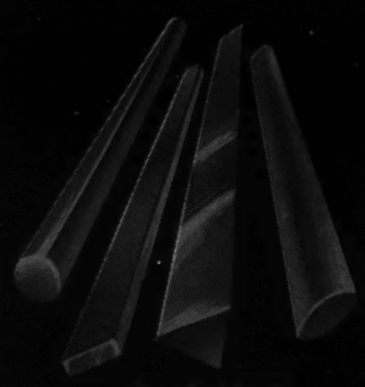


COILS

WIRE



TUBING



BARS

COPPER HUSSEY BRASS

AVAILABLE IN EVERY FORM FOR EVERY PRODUCT NEED

Yes, regardless of your product need, you'll find HUSSEY COPPER and BRASS are produced in the form you require. Sheet, strip, coils, bars, rods, wire . . . even plating anodes. Yes, in all commercially used grades, too, and in a highly refined quality that smooths out production, and increases your product quality.

Specify Hussey with confidence for every copper and brass application. Completely stocked in our Chicago warehouse, Hussey Copper is "on the job" to fill your specifications.

C. G. HUSSEY & COMPANY
(Division of Copper Range Co.)
ROLLING MILLS AND GENERAL OFFICES
PITTSBURGH 19, PA.

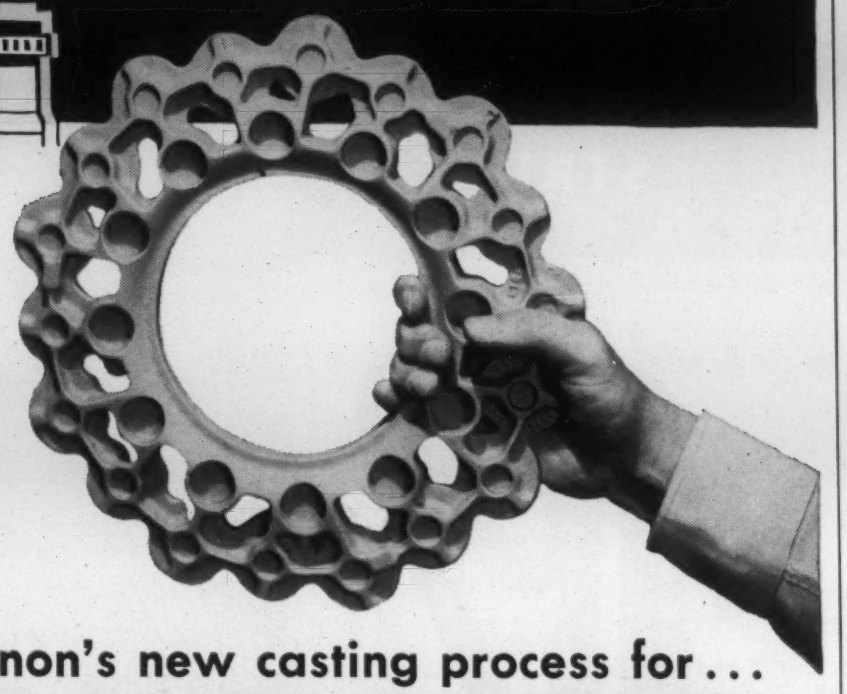
HUSSEY

● *7 Convenient Warehouses*

PITTSBURGH (19)
2850 Second Avenue
CLEVELAND (14)
5318 St. Clair Avenue
ST. LOUIS (3)
1620 Delmar Boulevard
PHILADELPHIA (30)
1632 Fairmount Avenue
NEW YORK (13)
140 Sixth Avenue
CHICAGO (18)
3900 N. Elston Avenue
CINCINNATI (2)
424 Commercial Square

For more information, turn to Reader Service Card, Circle No. 398

CERAMICAST*



Typical of the intricate design and thin metal sections possible with the CERAMICAST process is this backing plate for a jet aircraft brake.

Lebanon's new casting process for . . .

CLOSE TOLERANCE STEEL CASTINGS AT LOW COST

FOR QUALITY

TOLERANCES as close as ±.003″ to .005″ per inch.

INTRICATE SHAPES: Ideal for castings of complex design.

THIN SECTIONS: Metal sections to 3/32 of an inch. Knife-like edges to .030″ or less.

SMOOTH SURFACES: Variations held to 125 micro-inches or better.

FOR PRICE

LOWER PRODUCTION COSTS: Jobbing wood or metal patterns can be used. Design changes quick and inexpensive.

REDUCED MACHINING COSTS: Smooth, accurate castings greatly reduce or eliminate machining.

SHORT LEAD TIME: Because of easily constructed pattern equipment and relatively simple production process.

ADAPTABLE TO MANY CASTING SIZES AND ALLOYS—casting weights up to one hundred pounds or more. Carbon steel, conventional low alloys, stainless steels and the superalloys.

SEND US YOUR BLUEPRINTS. Our sales engineering department will show you how the revolutionary Lebanon CERAMICAST Process can be adapted to your project design.

*produced under licensing agreement with Shaw Processes, Ltd., London, England.

CIRCLE L ®

LEBANON STEEL FOUNDRY

113 LEHMAN STREET LEBANON, PENNSYLVANIA

CARBON, LOW ALLOY AND STAINLESS STEEL CASTINGS

For more information, turn to Reader Service Card, Circle No. 388

CONTENTS NOTED

Philadelphia Electric Co.

Turbine wheel fracture

Most probable cause of fracture was found to be a combination of residual stresses not removed by heat treatment, unusually low long-time high temperature ductility, and thermal stressing of the first-stage wheel due to admission of wet steam from the steam-seal regulator piping.

Results of detailed study of the failure at Tanners Creek were presented in a paper by A. W. Rankin and B. R. Sequin, of G-E. The high temperature fracture of the unit was particularly puzzling in view of the low stress levels used in designing, as well as the almost total absence of untried structural features. Subsequent inspection of duplicate units indicates the soundness of the structural design. The rotor forging was a 0.3 carbon, 1 chromium, 1.25 molybdenum, 0.25% vanadium rotor alloy, with a rough machined weight of 72,000 lb, length of 19 ft, and maximum diameter of 61 in. It passed successfully all normal quality control tests.

Vibration tests as well as metallographic studies showed that fatigue was not a contributing factor, while inspection of operating records indicated that fracture was not caused by unusual or harmful operating conditions. Both short-time and long-time rupture tests proved that the material was not lacking in high-temperature strength. Brittle nature of the radial crack suggested that embrittlement had played a significant part, but no significant embrittlement or notch sensitivity could be demonstrated in any physical test, even under severe notched conditions.

Tests strongly indicated that the fracture was due primarily to a continuously maintained stress which ultimately equaled its rupture life, with the brittle nature being due to intergranular mechanism and the multiaxial stress configuration. The excellent correlation with rupture strength of

You Get MORE THAN JUST AMMONIA

When You Order from *Nitrogen Division!*

You get experience

Anhydrous Ammonia was first produced in this country in 1890 by the Allied Chemical organization. Continuous development since then has led to an accumulation of Anhydrous Ammonia "know-how" unequaled in the industry!

You get multi-plant production

Nitrogen Division has three producing locations. This means you are *always sure* of supplies when you order from Nitrogen Division! Each plant manufactures to the extremely high standards originally set for industry by Nitrogen Division.

You get strategic location

Each of the three plants is located on water, on key rail lines and highway facilities in the heart of heaviest consuming areas. Plant locations at Hopewell, Va., South Point, Ohio and Omaha, Nebraska assure rapid delivery, even on short notice.

You get finest technical service

Only Nitrogen Division, with its unmatched years of experience, can offer such highly competent technical service. Free to all users and potential users of Ammonia, Anhydrous and Liquor, it brings you the benefit of wide experience gained from participation in all types of production and research programs.

Call Nitrogen Division today

Find out how Nitrogen Division can help you. Whether your problem is service, delivery or research, you'll be nearer the solution as soon as you pick up the phone. Don't delay; call today!

NITROGEN DIVISION ALLIED CHEMICAL

Anhydrous Ammonia
Ammonia Liquor
Ammonium Sulfate
Sodium Nitrate
Methanol
Urea
Ethanolamines
Ethylene Oxide
Ethylene Glycols
Formaldehyde
Nitrogen Tetroxide
Nitrogen Solutions
U.F. Concentrate—85
Fertilizers & Feed Supplements

Allied Chemical

Anhydrous Ammonia is shipped in tank cars, tank trucks and in 150, 100 and 50-lb. cylinders. Ammonia Liquor is shipped in tank cars only.

NITROGEN DIVISION

ALLIED CHEMICAL & DYE CORPORATION
40 Rector Street, New York 6, N. Y.
Hopewell, Va. • Ironton, Ohio • Orange, Tex. • Omaha, Neb.

For more information, turn to Reader Service Card, Circle No. 402

Spincraft did it for Gulf Oil...

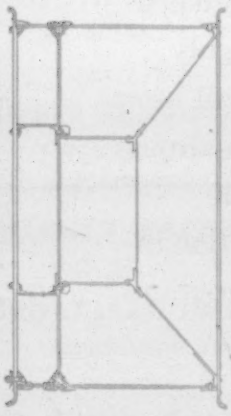
Spincraft can do it for you!

"Marsh Buggy" travels over rugged terrain on spun aluminum wheels

another example of spinning and fabrication by Spincraft

13 DIFFERENT OPERATIONS

The "Marsh Buggy" rolls on sturdy, lightweight aluminum wheels — spun and fabricated by Spincraft. Even if all four balloon tires fail, the spun aluminum air-tight wheel drums will keep the vehicle afloat. Wheel flange segments, extensions, .118" thick 52SO aluminum stiffener ribs, No. 11 U. S. gauge (.125" thick) stainless steel front hub cones were machined and assembled to complete the wheels. In addition to spinning, Spincraft performed the following operations: welding, grinding, polishing, machining, punching, braking, drilling, tapping, sawing, riveting, assembly and testing.



WHEN Gulf Research & Development Co., a division of Gulf Oil Corp., contracted to build their world-famous "Marsh Buggy" for the U. S. Army, Gulf called on Spincraft to fabricate all four wheel assemblies.

These huge wheels are designed to bear loads of 1,500 to 4,000 lbs. Combining strength with lightweight, these tough aluminum alloy wheels can take grueling cross-country punishment. The 10-ft. dia. tires easily negotiate swamp, water, sand, deep mire and other difficult terrain, at speeds from ¼ to 40 miles per hour.

This is another example of Spincraft's versatility and manufacturing skill. Complete facilities are available for all types of contract manufacture — finished parts, assemblies and complete products. Take advantage of our modern tools for spinning and fabricating. They can pay off in savings for you, too.

Write for Spincraft data book. If you have a specific problem, tell us about it — no obligation.

WORKSHOP OF AMERICAN INDUSTRY SINCE 1919

World's largest plant fully equipped for all types of metal spinning • deep drawing • stamping • fabricating

see our catalog in S or write for copy

Spincraft
SKILL WILL DO IT ®
INCORPORATED

4134 WEST STATE STREET • MILWAUKEE 8, WISCONSIN

CONTENTS NOTED

the calculated stresses at the notch opening, when the observed residual tension in the wheel rim was added to centrifugal stresses, suggests strongly that this combination supplied the continuously maintained stress.

The authors point out that the low long-time, high-temperature elongation of the rotor material cannot be ignored. It is possible that a material with greater elongation would have prevented progression of the crack down to the shaft. Also, the high stresses which may have occurred due to admission at trip-out of wet steam into the first-stage wheel space may have triggered the crack after most of the rupture strength and elongation were used up.

Corrective measures taken by G-E include measurements of residual stresses on all rotor forgings prior to machining; a modified heat treatment to give better long-time, high temperature ductility, though at some sacrifice in high-temperature strength; and modification of steam-seal regulator piping to minimize possibility of wet steam thermally stressing rotor wheels.

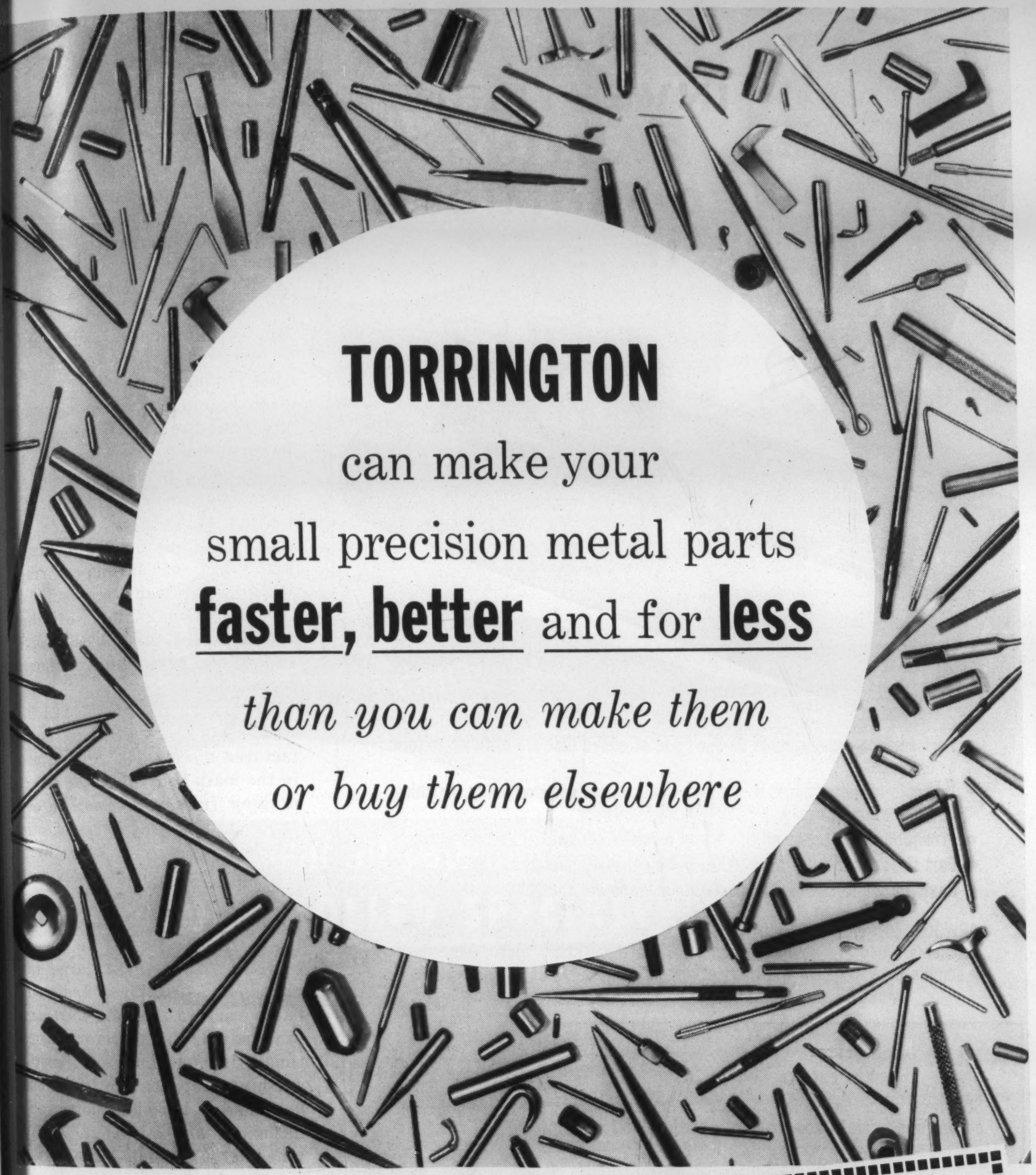
Also, investigations and developments are underway to produce a turbine rotor steel with improved high-temperature long-time ductility. Effects of vacuum pouring rotor ingots are also being investigated.

Spindle failure

Initiating cause of failure of the Ridgeland steam-turbine spindle was flakes or thermal cracks developed in the shaft during heat treatment. The flaws provided notches necessary to trigger the explosive burst of the shaft. The nickel-molybdenum-vanadium alloy currently specified is known to be susceptible to brittle failure in presence of notches in heavy sections.

Results of investigations to determine the cause of the bursting of the low-pressure spindle of the Commonwealth Edison steam turbine were detailed in a paper by

For more information, Circle No. 396



TORRINGTON

can make your

small precision metal parts

faster, better and for **less**

than you can make them

or buy them elsewhere

These are typical of parts that Torrington produces daily by the hundreds or millions. If you use similar small precision parts, mail the coupon today for the Torrington Small Precision Parts condensed catalog. Even better, send a sketch, blueprint or sample part. We will give you a prompt quotation which will mean substantial savings to you.

THE TORRINGTON COMPANY
Specialties Division
777 Field Street, Torrington, Conn.

TORRINGTON *SPECIAL* **METAL PARTS**

Makers of Torrington Needle Bearings

THE TORRINGTON COMPANY
Specialties Division
777 Field Street, Torrington, Conn.

☐ **Please send the Torrington Small Precision Parts condensed catalog**

☐ **Please have a salesman call**

Name_____

Title_____

Company_____

Address_____

City_____ Zone____ State____

For more information, turn to Reader Service Card, Circle No. 377

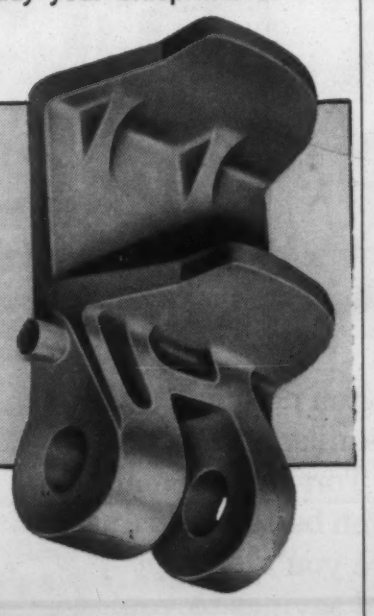
INVESTMENT CASTING IS ECONOMICAL IF...

- **Performance requirements demand use of alloys that are difficult to form or machine.**
- **Intricate shape or unusual contours cause expensive machining, finishing, and/or assembly costs.**
- **Production runs too small to warrant machine set-ups.**
- **Part sizes are smaller than 10″ or lighter than 10 pounds.**
- **Realistic tolerances and inspection standards are specified.**

ARWOOD engineers will gladly help you with your design and production problems. They are casting specialists. Let them study your blueprints or a sample part and save you time, effort and money.

A CASE IN POINT!
LIGHTER, STRONGER, CHEAPER

Stainless steel hinge for military ordnance component was formerly composed of a stamped bracket and machined hinge, welded together and assembled to a complicated anti-rotation device. Entire unit is now cast in one piece and is lighter and stronger. Hole-reaming is only machining required.



Write TODAY for your FREE copy of "A Critical Survey of Investment Castings", written especially for design and production engineers.

ARWOOD

ARWOOD PRECISION CASTING CORPORATION
74 Washington Street • Brooklyn 1, New York
Plants: Brooklyn, N. Y. • Groton, Conn. • Tilton, N. H. • Los Angeles, Calif.
"PIONEERS IN INVESTMENT CASTING"

For more information, turn to Reader Service Card, Circle No. 434

CONTENTS NOTED

H. D. Emmert, of Allis-Chalmers. The alloy was a 0.25-0.35 carbon 2.50-3.50 nickel, 0.25-0.75 chromium, 0.40-0.60 molybdenum, 0.05 min vanadium material which is generally in accordance with ASTM Specification A293 Class (Carbon and Alloy Steel Forgings for Turbine Rotors and Shafts).

Investigation showed that initial failure originated at the bore within the main body and progressed in a longitudinal plane both radially and toward the shaft ends, tending to split the main body into two halves. Extension of primary failure into shaft ends was limited by clamping effect of shrunk-on rings which set up high stresses in fillet corners. Combination of these forces caused the explosive splitting of the shaft into four major segments.

Production records showed that sonic tests by the forging manufacturer disclosed a general area in the main body in which defects ranging from very small to over 100% of the sonic back-reflection existed. It was considered by all that the sonic indications were inclusions and stringers of a harmless nature. Hydrogen flaking is a major problem in the successful production of large turbine-spindle forgings. Individual flakes vary in size and ultrasonic examination is therefore sometimes indeterminate in distinguishing between an individual flake and a harmless nonmetallic inclusion or shrinkage cavity. Whereas ultrasonic-test characteristics of flakes are fairly well established today, they were not understood to this degree four or five years ago when the Ridgeland spindle was produced. This accounts for the judgment at that time that the forging contained harmless inclusions rather than the more dangerous flakes.

The authors stress the need for continuing study of factors influencing notch sensitivity, such as composition, heat treatment, microstructure and processing. They also point out encouraging

Fill all your
COLD ROLLED SPECIALTY STEEL
needs at Crucible

You'll find, at Crucible, dozens of *prescription-made* cold rolled steels designed for special applications . . . steels for automotive stampings, business machine parts, saw blades, cutting dies, skates, springs and cutlery – to name just a few.

You'll find them in the widest possible variety – including carbon spring, alloy and stainless steels – in fact, in *any* ferrous analysis that can be cold rolled. And you're *sure* of *quality* at Crucible – the nation's leading producer of *special purpose steels* – for Crucible maintains *complete* control of production from ore to finished steel.

So when you need prompt delivery of *any* kind of cold rolled specialty steel *call Crucible.* Experienced Crucible metallurgists can help, too, in selecting the *best* steels for your job. And write for your free copy of Crucible's new 32-page booklet on cold rolled specialty steels. It's packed with useful data. *Crucible Steel Company of America, Henry W. Oliver Building, Pittsburgh 30, Pa.*

CRUCIBLE first name in special purpose steels

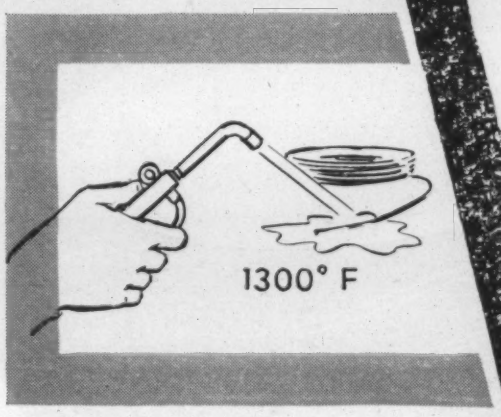
Crucible Steel Company of America

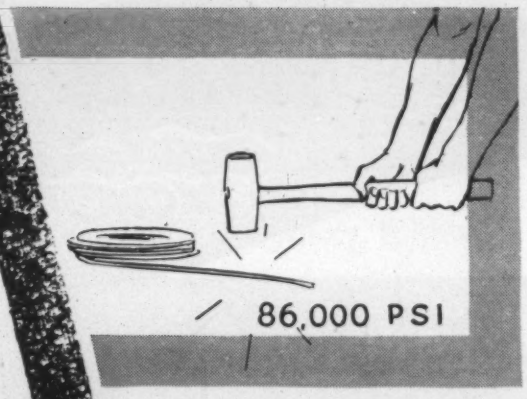
For more information, turn to Reader Service Card, Circle No. 373

Right down the line

UNITED'S PHOSON alloys

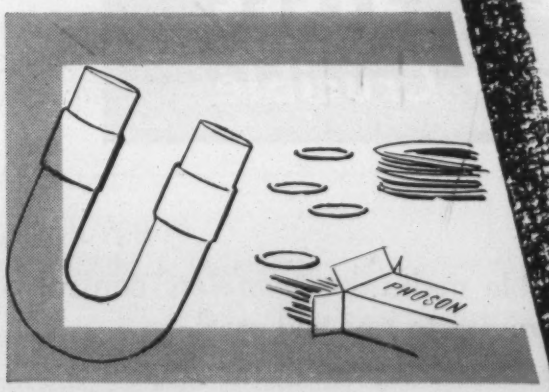
Right every time for brazing copper and brass





Here's Why:

Lowest practical brazing temperatures. There's a Phoson Alloy to meet your every requirement.



Super-Strength—Corrosion Resistant. Joints are stronger than metals brazed. Original tensile from 86,000 p.s.i. Highly resistant to most types of corrosion and generally equal to copper itself.

Join better by brazing
Join best with PHOSON or SIL-BOND.

Choose Sil-Flux for every fluxing need.

High Capillary Attraction and Versatility. Provides outstanding free flow and deep penetration. Ideal for preplacement or face-fed application. Efficient in both tightly-fitted or more loosely-fitted joints. Phoson Alloys are available in straight lengths, coils or preformed rings. *Contact your United Welding Supply Distributor or write*

Permanently United

UNITED WIRE
AND SUPPLY CORP.
Brazing Alloy Division
PROVIDENCE 7, R. I. • OFFICES IN PRINCIPAL CITIES

LOOK TO UNITED FOR THE BEST IN ALUMINUM, COPPER AND BRASS TUBE AND WIRE.

For more information, turn to Reader Service Card, Circle No. 463

improvements in ultrasonic in spection techniques and equip ment, and the importance o increasing knowledge of interpre tation of test results.

Rotor fractures

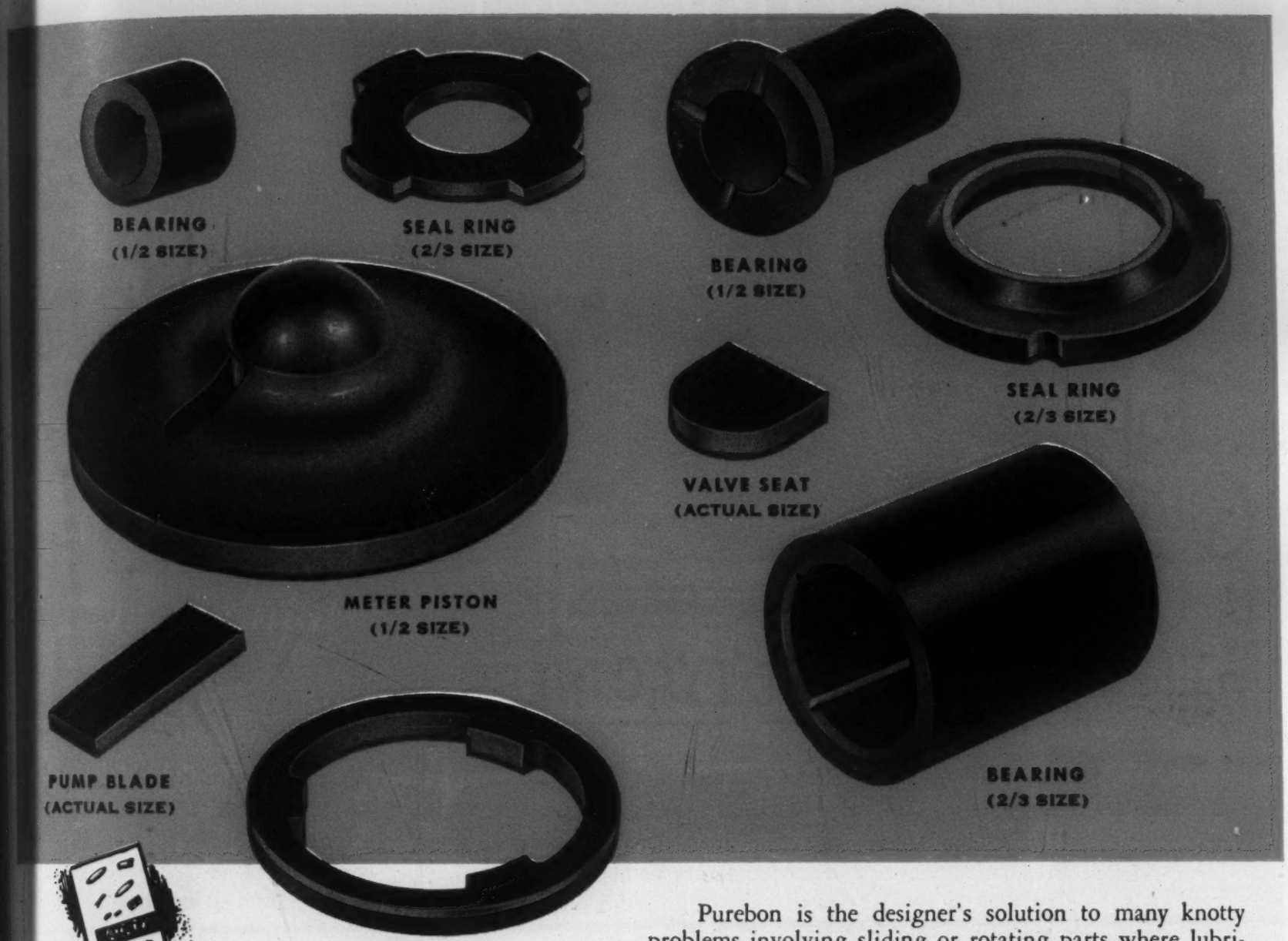
The Arizona and Cromby roto bursts were caused by unusua and severe stress concentration combined with the characteristic of the material of which the were made. In the Arizona roto concentrations were created b internal cracks which were mis interpreted during ultrasonic test ing. Concentrations in the Cromb rotor were created by a row o holes drilled for attachment o repair teeth.

Results of these investigation were reported in a paper by C Schabtach, E. L. Fogleman, A W. Rankin and D. H. Winne o G-E. The Arizona rotor was o an alloy with a ladle analysis o 0.29 carbon, 0.90 manganese, 2.5 nickel, 0.55 molybdenum, 0.05 va nadium, 0.05 chromium, 0.05 phosphorus, 0.024 sulfur, 0.25 silicon. The finished rotor was 39 in. in diameter and 15 ft long. The forging was unique in two respects: 1) the number of large indications observed during ultra sonic testing of the forging was greater than in any other forging accepted since sonic testing of rotors was begun in 1947; 2) a series of plugs had been shrunk into the bore to increase its mag netic capacity. Though the best methods of nondestructive exami nation known at the time were used, ultrasonic indications were interpreted as caused by harmless dirt and slag. The shrink fit of the plugs in the bore caused some increase in critical stress levels at operating speed, but are not believed to have been the primary cause of failure.

The Cromby rotor was of an alloy of similar composition. As received from the vendor, the forging was 36 ft long with a main body 43 in. in diameter. The rotor had a row of holes drilled

. . . the solution to your Lubrication problem is here . . . PUREBON

Carbon-graphite especially designed for mechanical applications.



For complete information about PUREBON. Write for Bulletin 52

COMPRESSOR BLADE
(2/3 SIZE)

Purebon is the designer's solution to many knotty problems involving sliding or rotating parts where lubrication is difficult and sometimes impossible. Purebon parts are molded or machined exactly to our customers' specifications here in our own plant, under our close supervision and inspection. *Because of the diversified characteristics of Purebon, applications are limited only by the designer's imagination.* If you have a problem involving insufficient lubrication at critical points of friction, our design engineering department will be happy to work with you toward its swift and successful solution.

PUREBON'S PROPERTIES

1 ***MOLDED TO SIZE—FOR MANY APPLICATIONS***
Tolerances of approximately 1½% of dimension required for molding most shapes.

2 ***SELF-LUBRICATING—OR BY THE MATERIAL HANDLED***
Varies with grade of Purebon.

3 ***STRONG AND TOUGH***
Transverse strength varies from 4,000 to 13,000 lb./sq. in. according to grade.

4 ***READILY MACHINABLE***
Tolerances as close as .0005 can be maintained where required.

5 ***CHEMICALLY INERT—NON-TOXIC***
Resistant to attack by chemicals of all kinds, used in food handling and processing equipment.

6 ***HIGH TEMPERATURE APPLICATION***
Most Purebon grades will operate efficiently in temperatures up to 700°F in air or much higher in neutral or reducing atmosphere.

Leaders for over 40 YEARS in PURE CARBON PRODUCTS

PURE CARBON CO., INC.
450 HALL AVENUE
ST. MARYS, PENNSYLVANIA

For more information, turn to Reader Service Card, Circle No. 452

Top
QUALITY
CONTROL
calls for RECORDED EXACTNESS

Myriads of details go hand in hand with Quality Control. For one example, at the onset of production, a casting is "destroyed" by sectionalizing to determine dimensional accuracy. Irregularities can be corrected, molding methods acknowledged, and the general structure can be proved before subsequent costs are expended.

As illustrated above, the transparent "sectional template" visually approves interior members and voids, as well as outlines finish surface adequacy for the record.

Complete progress is recorded, and any time after inception —costs, revisions, equipment function, production details . . . and even difficulties encountered can be itemized with exactness.

It all adds up to *top quality control* service. This service can be *your* service. Write or call for complete information.

UNITCAST CORPORATION, Toledo 9, Ohio
In Canada: CANADIAN-UNITCAST STEEL, LTD., Sherbrooke, Quebec.

Unitcast QUALITY STEEL CASTINGS

For more information, turn to Reader Service Card, Circle No. 455

CONTENTS NOTED

and tapped to hold studs used
repair damage caused by brea
ing of a milling cutter duri
machining of the coil slots. Th
has been a standard repa
method for generator rotors. T
corner of a stud hole at which t
primary fracture originated w
in an area of alloy segregati
in which stringlike regions
above-average alloy content e
isted. Strength and ductility
the metal in these segregatio
is low.

Hydrogen content of both roto
caused ductility of the material
be lowered significantly. Howeve
it is believed not to have been th
cause of the brittle nature a
rapid propagation of the fra
tures throughout the rotors. I
the Arizona rotor, hydrogen ma
have contributed to formation
the internal cracks during manu
facture though the amount
hydrogen present was at th
lower end of the range normall
associated with hydrogen flaki

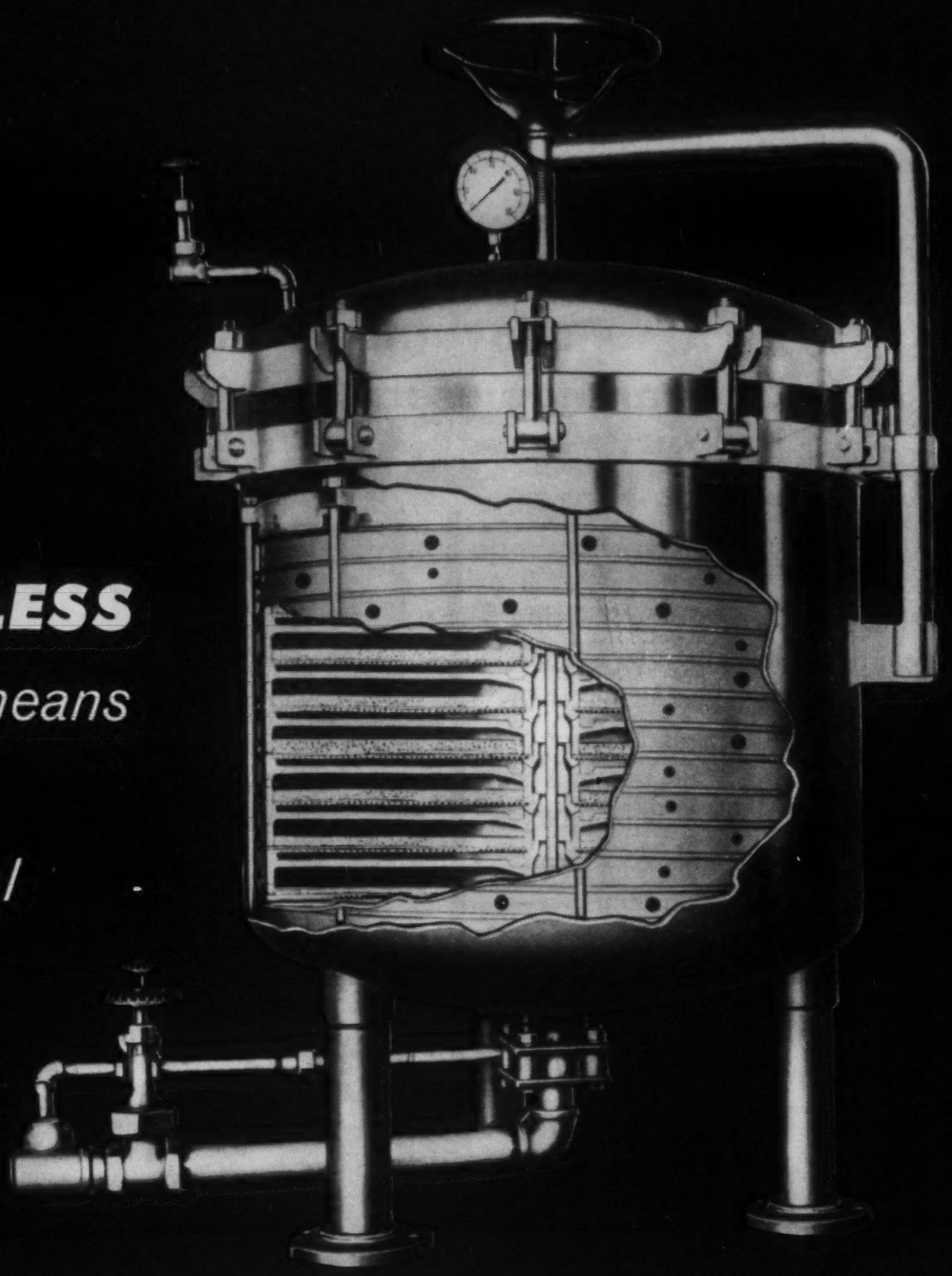
Until better materials are d
veloped, the authors stress th
need for use of more stringe
ultrasonic acceptance tests, di
continuance of tooth repair wi
studs, and improved desig
manufacture and inspection tec
niques.

Economical Strip and Wire from Metal Powde

A new method of continuous
producing metal strip, and wir
from powdered metal has bee
developed which promises to b
somewhat competitive with stri
and rod rolled from ingots an
blooms. Results of the proces
were described by J. D. Shaw an
W. V. Knopp of S-K-C Researc
Association at a meeting of th
Powder Metal Group of the Ame
ican Institute of Mechanical En
gineers last December in Ne
York.

Essentially the process entail
recovering metal powders fro
scrap by a chemical leaching pro
ess, compacting the loose powde

what
ALL-STAINLESS
design means to horizontal plate filters...



Crucible stainless steel, type 304, is used throughout this Sparkler standard horizontal plate filter.

Constant filtration of chemicals, pharmaceuticals, foods and liquids subject this horizontal plate filter to pretty rugged corrosive, abrasive and temperature conditions. That's why Sparkler Manufacturing Co. uses all-stainless steel construction.

For stainless, first of all, fights off corrosive attack. And it's strong. Stainless becomes tougher the more it's used . . . which is another way of saying that, with stainless, abrasion is no problem. And neither is cleaning. For stainless steels' smooth, bright surface comes clean with a minimum of effort . . . stays clean longer.

The fact is, stainless makes any equipment stronger, longer-lasting, easier to use. Check with your local Crucible representative for help in selecting the best stainless grade for your job. Or write *Crucible Steel Company of America, The Oliver Bldg., Mellon Sq., Pittsburgh 22, Pa.*

CRUCIBLE first name in special purpose steels

Crucible Steel Company of America

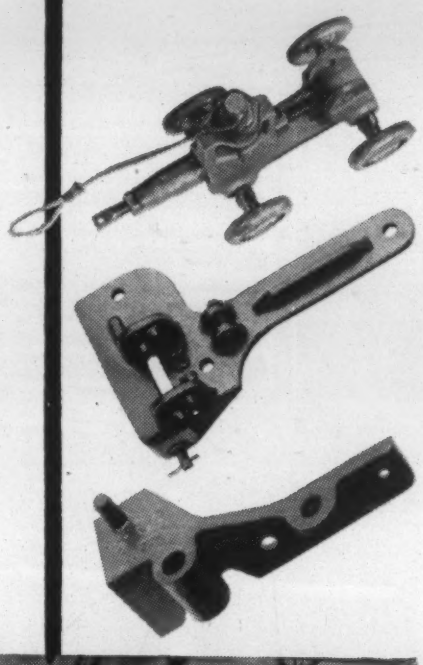
For more information, turn to Reader Service Card, Circle No. 404

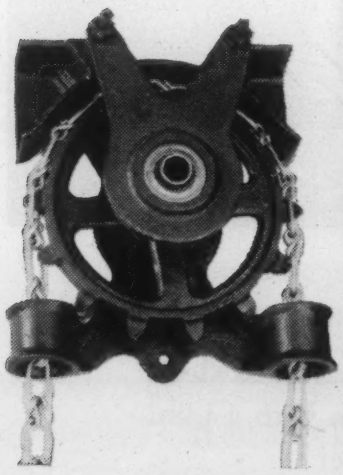
How About Malleable?

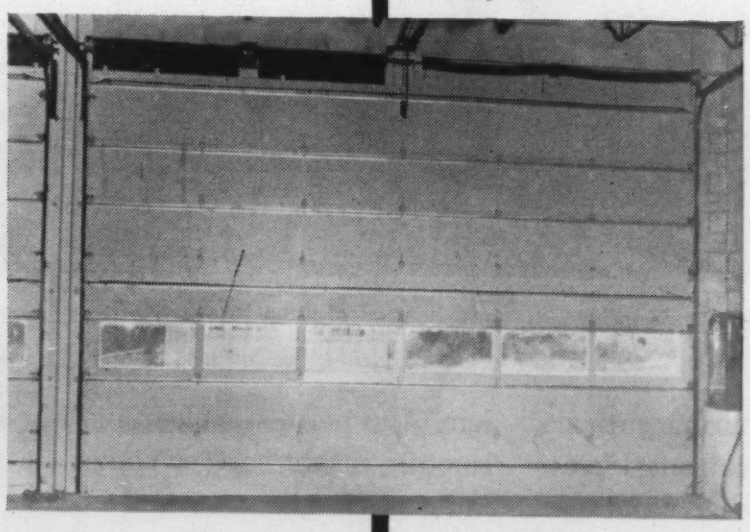
"Sturdiness and permanence pay," says a leading overhead door manufacturer.

Here is another manufacturer using malleable iron castings to improve his product. Malleable is noted for its tough strength, wear resistance, and ability to be produced in intricate shapes close to final form. Its excellent machinability, where machining is required, means trouble-free and low-cost finishing.

This versatile material has been utilized for 130 years in a wide range of applications and in every industrial field.







Call a malleable foundry and review your products with their engineers. They can often give you valuable suggestions. Or write to the Malleable Founders' Society.

Parts photos by courtesy of Quincy Mfg. Co., Tiffin, Ohio

Malleable FOUNDERS' SOCIETY

1800 Union Commerce Building — Cleveland 14, Ohio

For more information, turn to Reader Service Card, Circle No. 449

CONTENTS NOTED

into green strip or rod between rolls, and sintering. Resulting sheet or rod is then rerolled to gain desired mechanical properties. Process has been used successfully with copper, brass, bronze, Monel, iron, nickel, stainless steel, and silver.

Process

Metal powders are currently more expensive than metal in ingot form. For example, copper powder now costs about 14 cents more per pound than copper ingot. Therefore, obtaining sheet and rod from powder would be useful only for alloys which are virtually impossible to economically melt successfully. The new process, presently called roll-bonding, uses powders from lower grades of scrap which cannot be remelted into ingots of good quality. Such scrap is obtained from furnace ashes from brass and copper operations, turnings, sweepings, clad iron scrap, and generally the number three and poorer grades. The scrap is freed of organic contaminants by a leaching action after which the copper is precipitated as high purity powder.

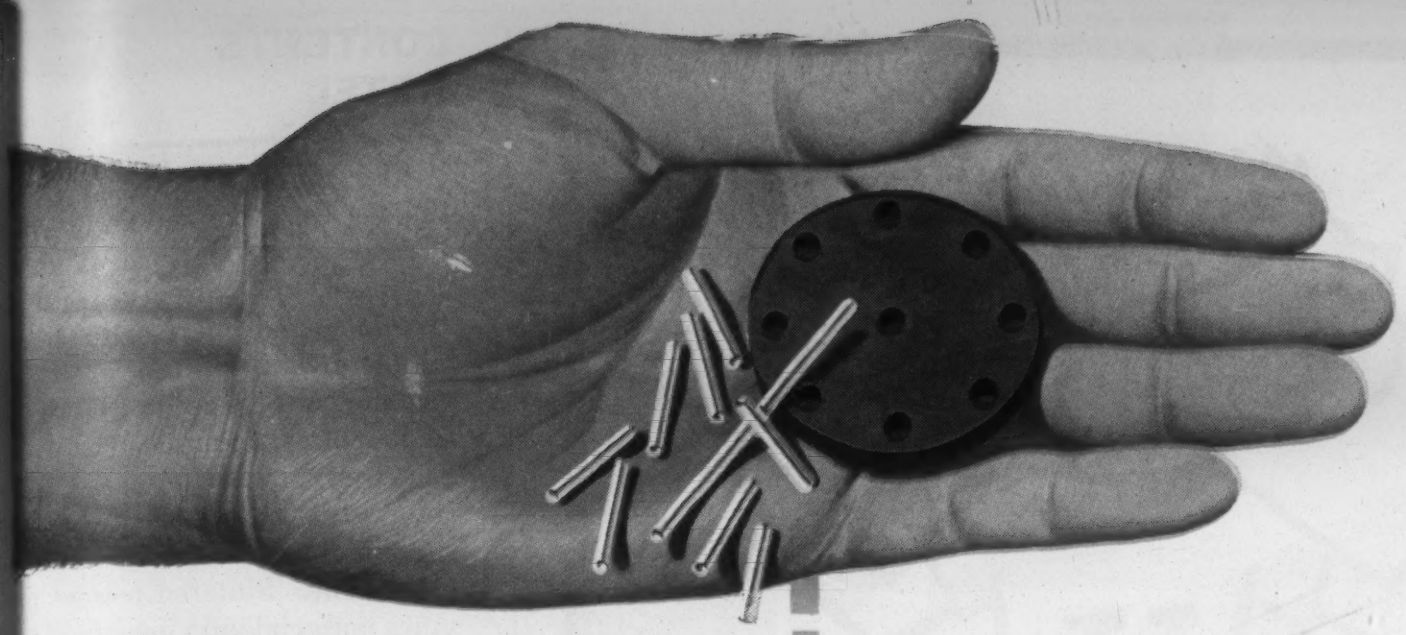
Powders

Powders produced by carbon monoxide reduction are coarse and tend to be spherical, with an apparent density of 2.64 g/cc, a relative flow of 29.1 sec or 135% with 0.4% of –325 mesh and more than 50% of 80 mesh. As rolled strip has a green density of 7.02 g/cc and green strength of 700 psi tensile. Sintered, carbon dioxide-produced powders provide density of 6.85 g/cc, strength of

TENSILE PROPERTIES OF POWDER METAL STRIP

	T. S., psi	Elong, % in 1 in.
Copper	40,100 39,000	34[1] 24.5
Brass (70–30)	54,000	45
Monel	75,000	28.8

[1] *Note difference in elongation of two thicknesses of copper strip. Rather than real, this difference might be a function of difficulty of testing such thin strip without tearing.*



PAY LESS FOR MORE RUGGED

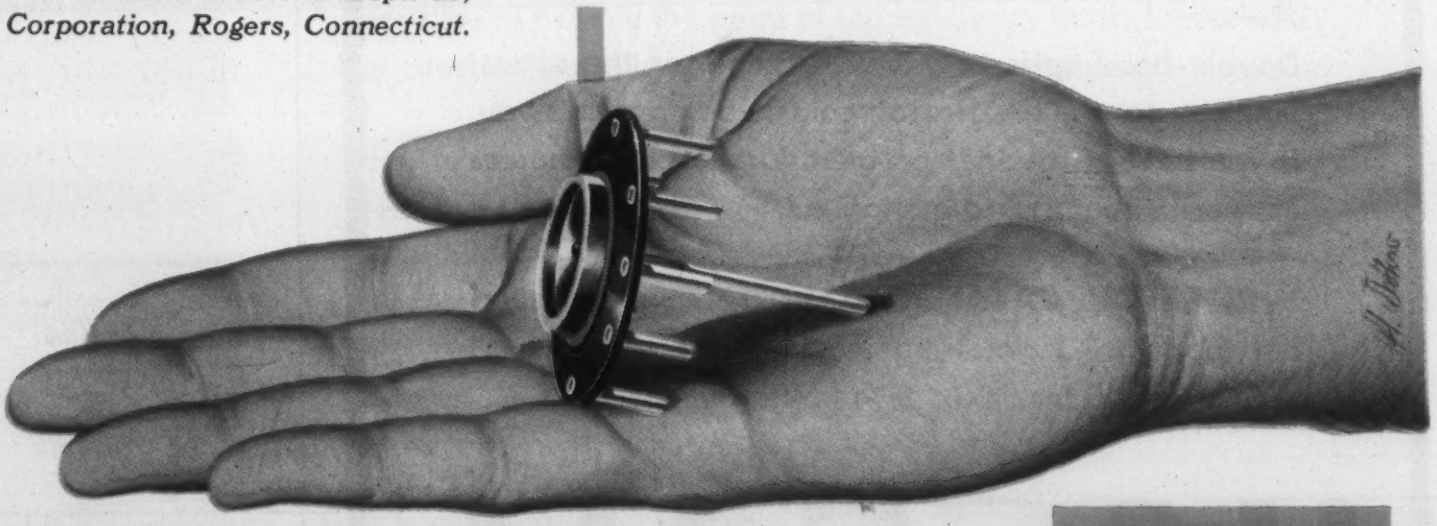
PLASTICS WITH MOLDED-IN METAL COMPONENTS

USE ROGERS PHENOLIC SHEET MOLDING MATERIALS

Three series of Rogers phenolic *sheet* molding materials are available: RM 9275, a cellulose-filled grade with an impact strength of 1.8; RM 4000 grades, glass-cellulose reinforced, with impact strengths ranging from 4.0 to 7.0; and RM 2035, an electrical grade, designed when properly molded to meet electrical standards equivalent to NEMA XXXP laminate. *Please write for data sheets to Dept. M, Rogers Corporation, Rogers, Connecticut.*

MAKE THIS COMPARISON AND SEE WHY

ROGERS PHENOLIC SHEET MOLDING MATERIALS	CONVENTIONAL HIGH IMPACT PHENOLICS
Low bulk factor of 1½ to 1	High bulk factor of 10 or 12 to 1
Low cost shallow molds	Expensive deep molds
Preforms can be blanked and pre-drilled for accurate location with inserts	Volumetric loading or hand preforming makes for difficulty in locating material with inserts
Preforms blanked from sheets of uniform thickness form mold charges of exact weight	Mold charges difficult to measure — require exact weighing to avoid over- or under-charging
Fast, uniform preheating	Slower, less uniform preheating
Good to excellent moldability	Poor to fair moldability
Low tooling cost, simplified production molding, minimum rejects, low unit parts cost	High tooling cost, tricky, expensive molding operations, high reject rate, high unit parts cost



ROGERS CORPORATION

ROGERS, CONNECTICUT

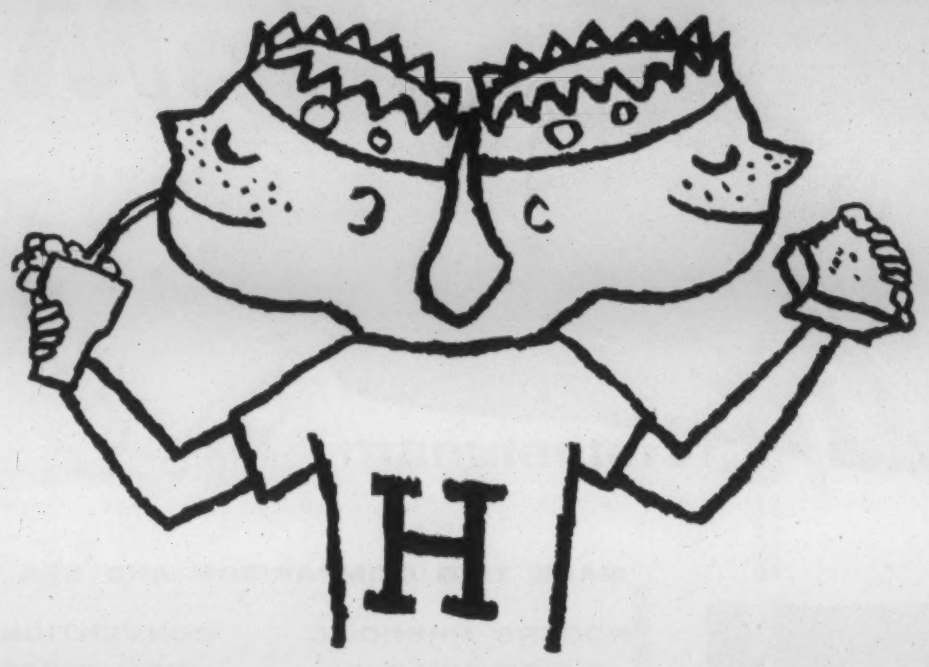
PRODUCTS

DUROIDS—for Gaskets, Filters, Electronic Devices, etc.
SHOE MATERIALS—for Counters, Midsoles, Liners, etc.
ELECTRICAL INSULATION—for Motors, Transformers, Generators, etc.
PLASTICS—Special Purpose Molding Compounds and Laminates.

SERVICES

FABRICATING—Including Combining, Coating, and Embossing.
DEVELOPMENT—Research and Engineering of New Materials, Parts, and Products.

For more information, turn to Reader Service Card, Circle No. 317



OFTEN

TWO HEADS ARE BETTER THAN ONE

Often two heads are the only solution to a part or fastener problem. Take just a moment to look at this pump valve-plunger. It's a tricky job calling for two heads and two different shaft diameters. The big problem here was to produce this valve-plunger in *quantity, inexpensively* and *quickly* . . . and Hassall double-heading did the trick.

Double-heading is only one example of the almost limitless possibilities Hassall cold-heading offers you. If you have a fastener problem just send us samples or specifications for a quotation.

WRITE FOR CATALOG . . . with it we will send our popular decimal equivalent wall chart.
John Hassall, Inc., Box 2174, Westbury, L. I., N. Y.

HASSALL

SINCE 1850

SPECIAL NAILS RIVETS SCREWS
Hassall

NAILS, RIVETS, SCREWS AND OTHER COLD-HEADED FASTENERS AND SPECIALTIES

For more information, turn to Reader Service Card, Circle No. 439

12,000 psi tensile, and 7.75% elongation in one inch. Powder produced by hydrogen reduction are finer and sharp with an apparent density of 1.20 g/cc, relative flow of 60.9 sec or 64.7%, and 48.3% of –325 mesh. Hydrogen-produced powder provides materials with green density of 5.9 g/cc, and green strength of 4300 psi tensile. Sintered powder provides material with density of 6.7 g/cc, strength of 16,400 psi tensile, and elongation of 10.3% in one inch.

Powder obtained from chips with 89% copper, mixed scrap with 92% copper, brass scrap with 71% copper and slag with 17.0 copper, 10 tin, 0.01 lead, 25.0 silicon dioxide and 10.8% iron has a composition of 99.95 copper, 0.001 lead, 0.007 tin, 0.001 nickel, 0.001 manganese, and 0.003% iron.

Forming

Powders are formed in horizontal steel rolls, designed to make either strip or wire rod. In the green form, strip is somewhat porous and has sufficient cohesion and flexibility to be wound on reels. Strip or rod is then sintered in a furnace for about 3 min. Pure metals are sintered rapidly, while alloy material requires longer times to permit diffusion. After sintering, the material is rolled, annealed, etc., to desired mechanical properties.

To produce wire, rod is rolled to 9% density, then drawn conventionally without lubrication. As yet wire has not been produced in finest sizes possible. To date wire has been drawn down to 0.0052 in. dia. Other possibilities include production of tube by this method, though no continuous process has yet been developed.

Brass and monel have been rolled as a laminate; however problems arise in differential shrinkage, allowing curling during sintering. Close control over densities is necessary.

Precautions

The speakers listed several precautions which should be ob-

make NORTHWEST products BETTER!

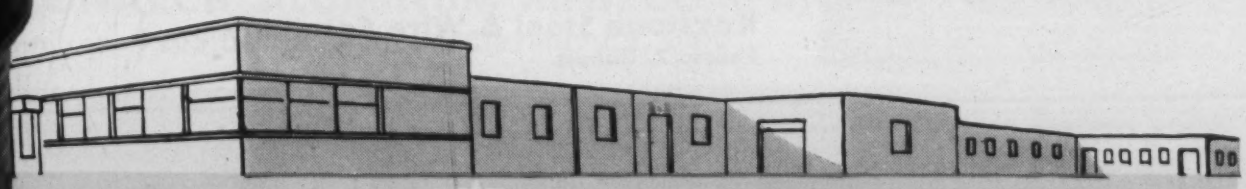
the invisible ingredients

Northwest Chemical quality is equal to any in the field. Their formulas are based on careful research and long experience. The steady growth of the company and the acceptance of their products is due to the invisible ingredients compounded in each shipment going into a customer's plant.

Those ingredients which give Northwest Chemical customers a superior product are the careful, individual attention given each customer's requirements, expert analysis of the job to be done plus the technical ability and experience to produce basic formulas to exactly the point of top efficiency in each case and by constant stand-by service, to keep them that way.

That is the reason Northwest Chemicals are specified by an ever increasing number of the country's top manufacturers.

Remember—the cost per finished article is the true cost of your cleaner. Northwest's stand-by service keeps the job right.



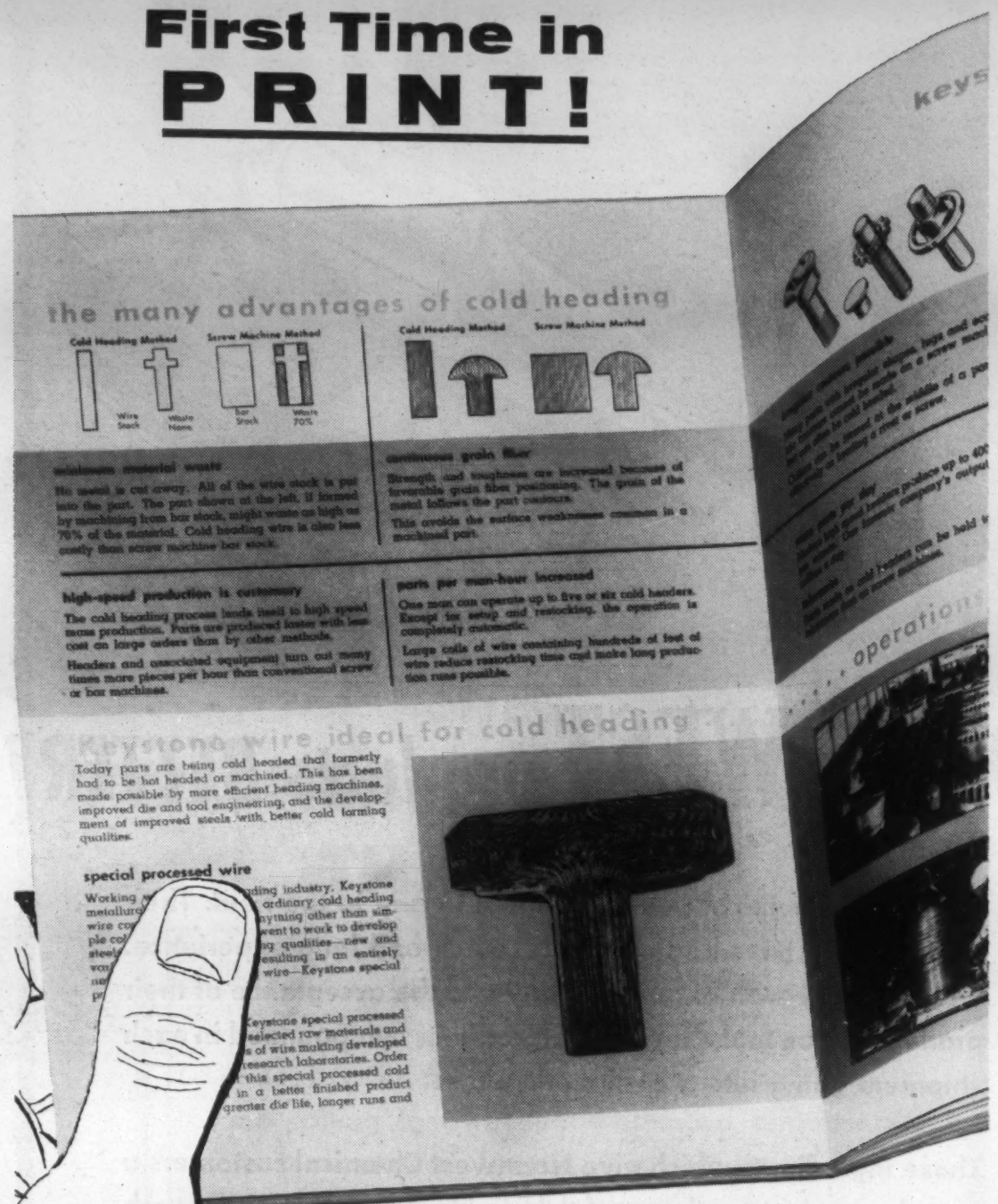
NORTHWEST CHEMICAL CO.

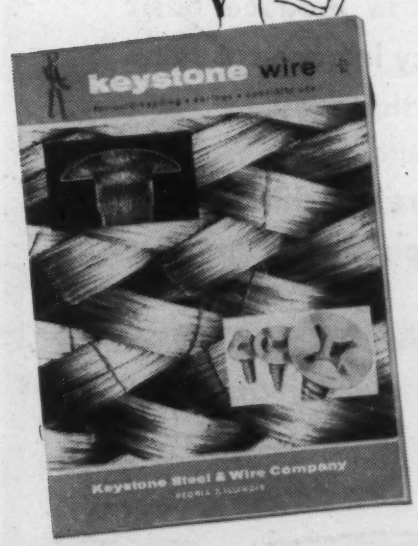
9310 ROSELAWN DETROIT 4, MICH.

pioneers in pH cleaning control *serving you since '32*

For more information, turn to Reader Service Card, Circle No. 446

First Time in PRINT!





The facts about COLD HEADING

SEND FOR THIS BOOKLET TODAY!

Every metalworking man—engineer, buyer, executive—should read this new booklet presenting many up-to-date facts about the *flowability* of Cold Heading Wire. It contains illustrations, diagrams, and technical facts useful to anyone in the modern, wire fastener industry. See how the most complicated and intricate parts can be cold headed. Mail coupon today for your free copy!

Keystone Steel & Wire Company
Peoria 7, Illinois

KEYSTONE STEEL & WIRE COMPANY, PEORIA, ILLINOIS
Please send me the new booklet on Cold Heading Wire. A13

NAME _____ TITLE _____
COMPANY _____
STREET _____
CITY _____ STATE _____

KEYSTONE WIRE *for Industry*

For more information, turn to Reader Service Card, Circle No. 314

CONTENTS NOTED

served: 1) Degree of reduction in mills must be limited to prevent transverse cracking; annealing temperature must be kept down to avoid grain growth; maximum thickness of material depends on its green strength; and generally, roll diameter must be about 100 x thickness of strip.

As far as speed of rolling is concerned, current material is being rolled at around 30 fpm, though the authors claim they are not near the limit yet. Wetness or dryness of the powder affects the speed of rolling. With wet powders, mills can run slower; with dry powders they must be run rapidly to keep the metal together.

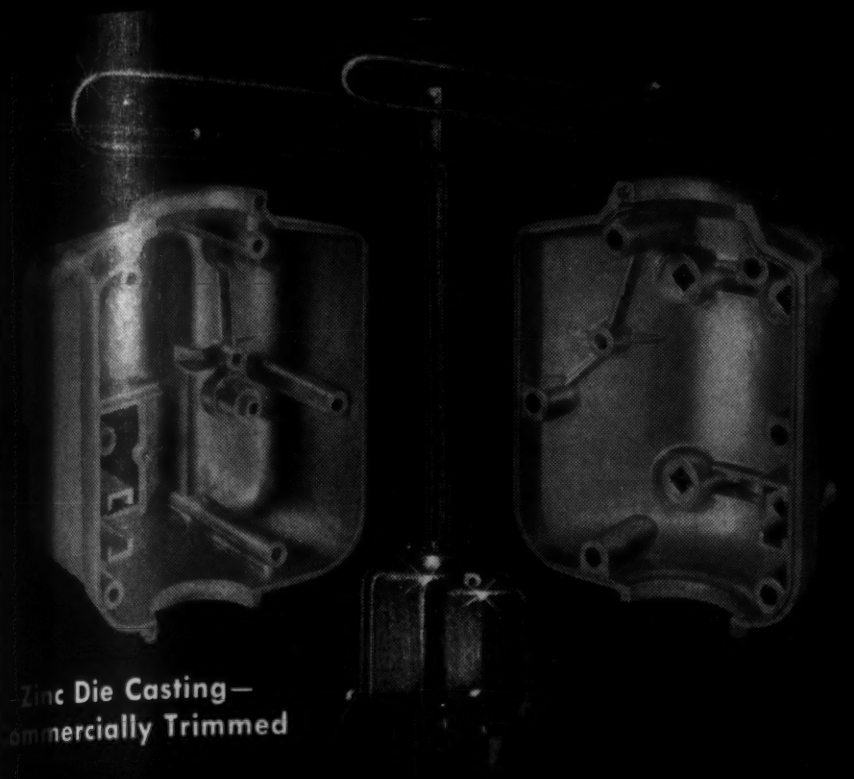
Self-Fluxing Brazing Alloys

By comparing some chemical and physical properties of lithium with those of some other strongly deoxidizing metals, it appears that lithium is the most suitable metal for developing self-fluxing brazing alloys. Results of experiments confirming this conclusion are detailed in an article by N. Bredzs and D. Canonico in last November's Welding Research Supplement to *The Welding Journal*.

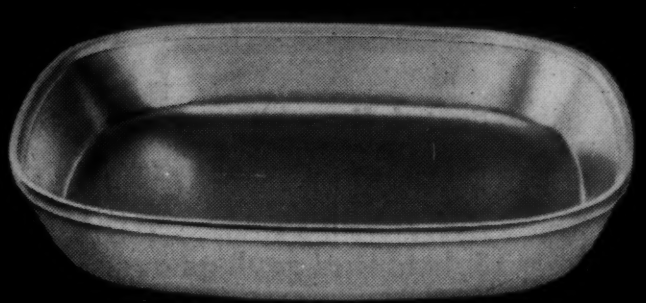
A molten 1 lithium-99% silver alloy not only reduces oxides on the surface of low carbon steel, drill rod and 303 stainless steel, but also considerably lowers the wetting angle of molten silver, thus promoting wettability and fluidity. Lithium bearing silver alloys and lithium bearing copper alloys should prove useful for brazing plain carbon steels as well as stainless steel without flux or reducing atmospheres. Tensile strength of such joints is quite high. Preplaced lithium bearing silver alloys and lithium bearing copper alloys should torch braze stainless steel in air without fluxes.

(Book Reviews on p. 192)

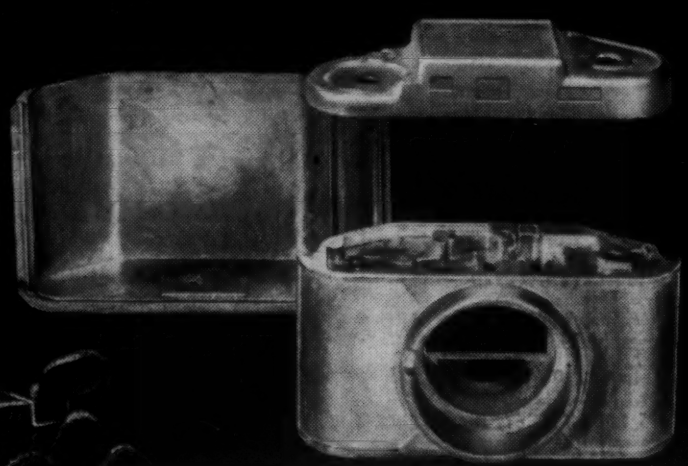
For more information, Circle No. 308



Zinc Die Casting—
ommercially Trimmed



Aluminum Permanent Mold
Casting—Machined & Velvaglazed®



Want more casting value per dollar?

Monarch pioneers in casting progress. Our casting and finishing facilities, unique in the industry, produce unusual casting performance. The job your casting must perform is economically accomplished with jobs we perform on the casting.

Illustrated are a few major industries capitalizing on Monarch's ability to guarantee top-value castings at factual, low end-cost.

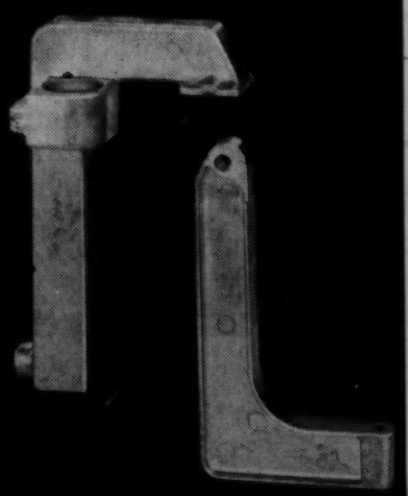
MONARCH
ALUMINUM
PIONEERS IN CASTING PROGRESS

MONARCH ALUMINUM MFG. COMPANY
9205 Detroit Avenue, Cleveland 2, Ohio

minum Die Casting—
ommercially Trimmed

Aluminum Permanent Mold
Casting—Velvaglazed®

Aluminum Die Casting—
Commercially Trimmed



Aluminum Die Casting—
Commercially Trimmed

For more information, turn to Reader Service Card, Circle No. 379

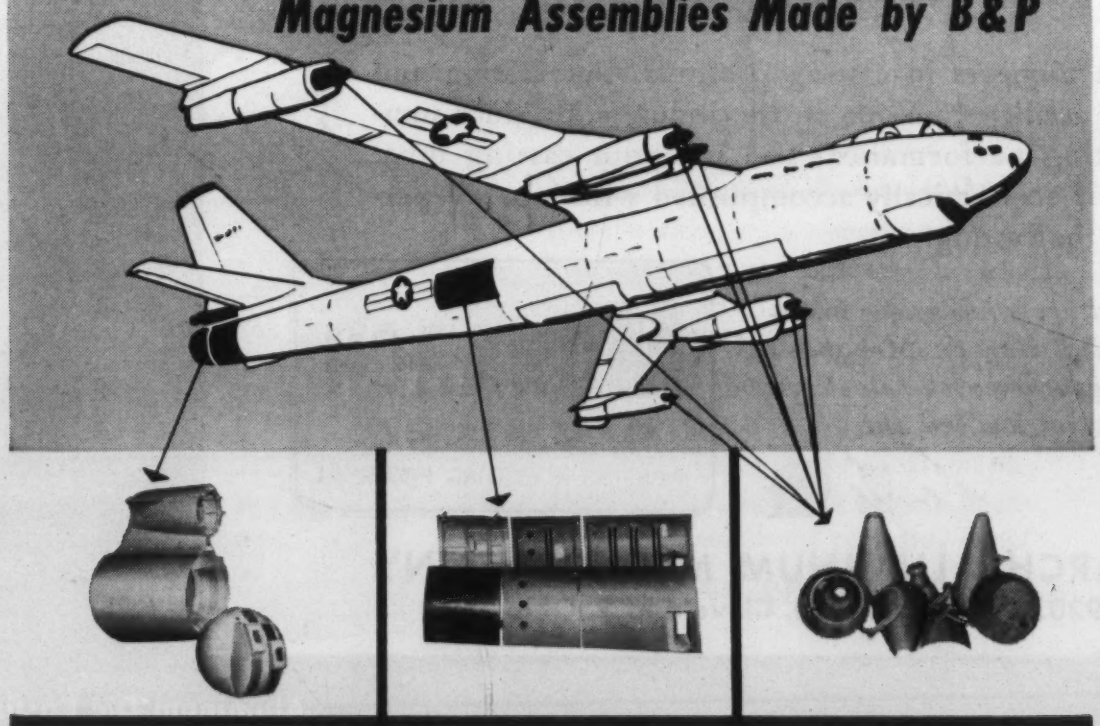
Fast delivery
Wide range of alloys
Custom made
Substantial savings over solid alloys

Prompt quotations gladly given on your specifications

The Home of Laminated Metals

The IMPROVED SEAMLESS WIRE COMPANY
Incorporated 1898
775 EDDY STREET, PROVIDENCE 5, R. I.

IN THE BOEING B-47 BOMBER:
Magnesium Assemblies Made by B&P



Tail cone and gun turret enclosure are supplied by B&P to General Electric Co.; smooth panel doors made for Lockheed and Douglas B-47 production; and the inboard and outboard jet pods for Bell Aircraft Co. In addition, B&P produces magnesium cases and components for electronics systems in the B-47 and many other military planes.

Write for folder describing B&P's facilities for magnesium and titanium work.

BROOKS & PERKINS, INC. 1960 W. Fort St. Detroit 16, Mich.
Offices in New York, Washington, Los Angeles and Dallas

For more information, turn to Reader Service Card, Circle No. 345

CONTENTS NOTED

BOOKS

Minerals Yearbook, Metals and Minerals (except Fuels), Vol 1, 1952. *Bureau of Mines, Minerals Div. Government Printing Office, Washington 25, D.C. 1955. Cloth 6 by 9 in. 1218 pp. Price $4.00.*

The latest edition of this well-known annual survey of progress in the minerals industry has been published in three volumes because the increase in material available made single-volume publication impossible. In the future, Vol 1 will cover the minerals and metals with the exception of fuels, Vol 2 will cover fuels and Vol 3 will discuss the industry on a geographical basis.

Vol 1 contains chapters on the commercial metals and minerals, a chapter reviewing the mineral industries, a statistical summary and chapters on technology. The data presented are largely based on information supplied by mineral producers, processors and users.

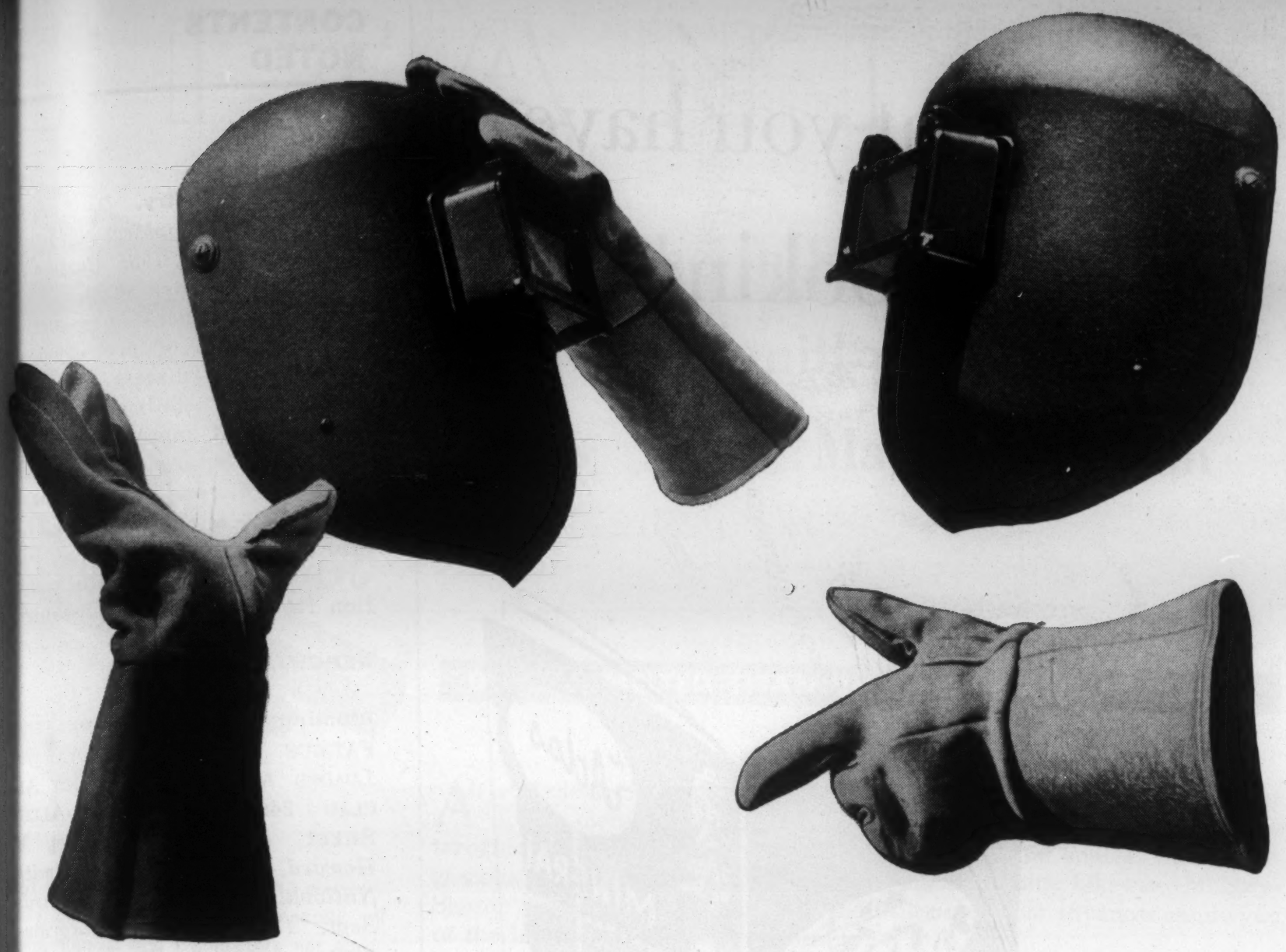
1954 Vacuum Symposium Transactions. *Committee on Vacuum Techniques, Inc., Boston 9, Mass. 1955. Cloth 8½ by 11 in. 147 pp. Price $10.00.*

This volume contains the papers delivered at a meeting held in Asbury Park, N. J., during June, 1954. Included are 9 papers on new equipment and instrumentation, 6 papers on methods and techniques for obtaining high vacuum, 10 papers on developments in fundamental vacuum technology, 9 papers on vacuum systems applications and processes and a report on recommended nomenclature.

Metal Finishing Guidebook Directory, 1956 Edition. *Finishing Publications, Inc., Westwood, N.J. 1955. Paper 5 by 8 in. 604 pp. Price $3.50.*

This handbook, devoted to metallic surface treatments, is issued yearly. It contains sections on surface preparation, plating solutions and operating data, analysis and plant engineering. A valuable feature is the listing of suppliers in the field and trade names of products.

(Continued on p. 194)



WHAT—*HANDLES LIKE CARBON STEEL?*

That's right. Worked with the same techniques as carbon steel, Lukens "T-1" steel can be readily welded without special joint designs or procedures.

Although Lukens "T-1" steel is a tough, high strength, heat treated steel, designers and engineers will find that its ready weldability and excellent wear characteristics will pay off in design freedom and increased equipment efficiency. Because this low carbon, quenched and tempered steel poses no unusual problems in welding, equipment can easily be fabricated, modified or repaired not only in the shop but also in the field. Three times stronger than carbon steel, this new steel has lighter weight and reduced thickness in comparison to heavier, thicker plates of carbon steel, thereby reducing material, construction and shipping costs.

Lukens' range of steel plate sizes—including the widest and heaviest plates available anywhere—makes possible additional savings through the use of wider plates that require fewer welded seams. Lukens "T-1" steel's resistance to the combination of wear and impact abuse lowers maintenance and replacement costs, lengthens equipment life.

The latest addition to Lukens' complete line of carbon, alloy and clad steels, this new steel's unusual combination of properties suit it especially to applications in pressure vessels, bridges, shipbuilding, construction machinery and general industrial equipment. On problems of design, material selection, application and fabrication techniques, Lukens offers full technical assistance. If you would like further information on Lukens "T-1" steel, write to: Manager, Marketing Service, 776 Lukens Building, Lukens Steel Company, Coatesville, Pennsylvania.

LUKENS

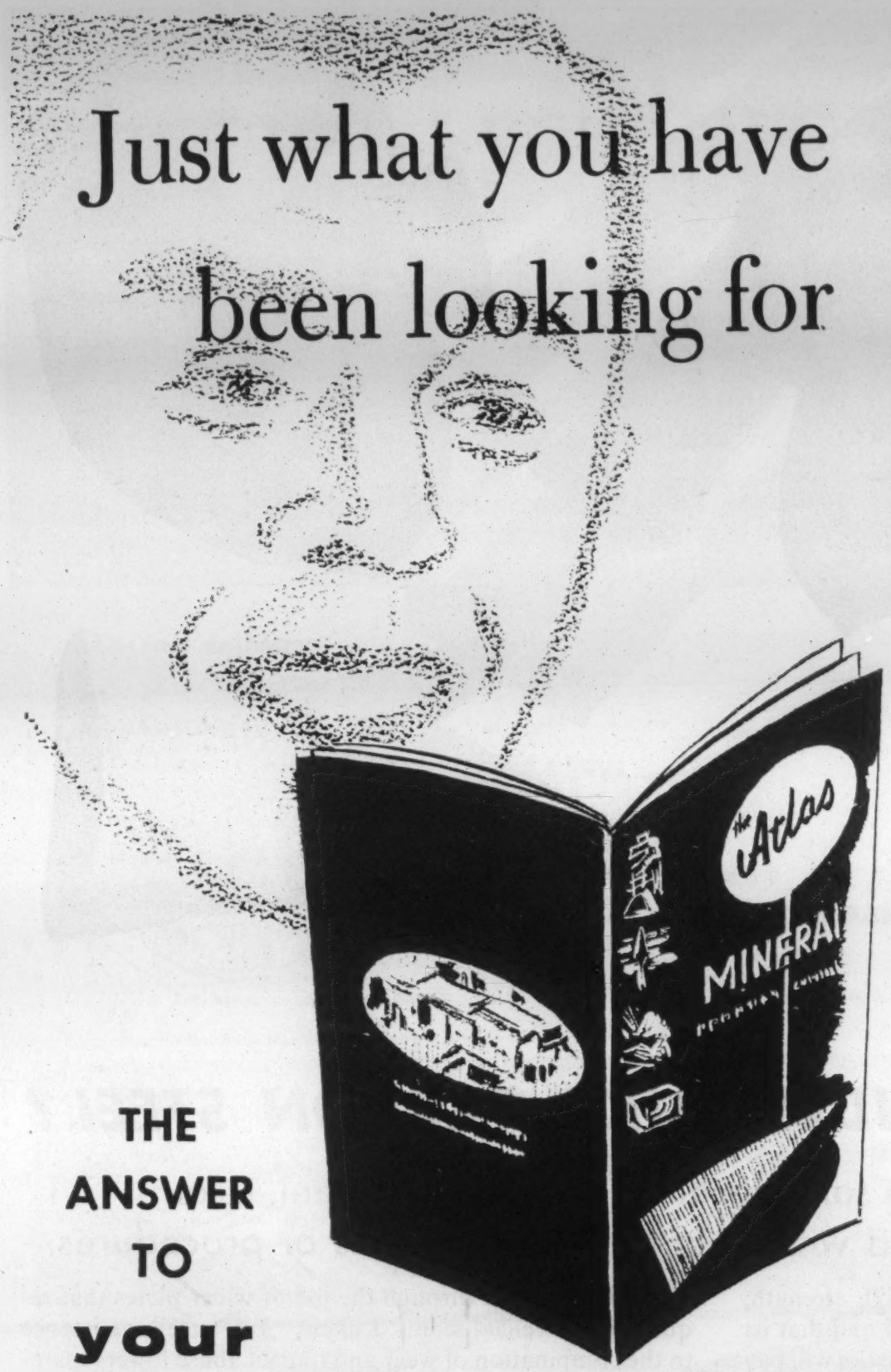
"T-1" STEEL

To get the new, 28-page book on Lukens "T-1" steel, ask for Bulletin 781.

THE NEWEST IN A COMPLETE LINE OF ALLOY STEELS

LUKENS STEEL COMPANY, COATESVILLE, PENNSYLVANIA

For more information, turn to Reader Service Card, Circle No. 422



THE ANSWER TO your corrosion problems

A completely new sixteen page bulletin on corrosion proof materials of construction. . . . Individual sections on CORROSION PROOF CEMENTS, PROTECTIVE COATINGS, TANK LININGS and RIGID PLASTIC STRUCTURES and PIPE . . . also sections including engineering design and corrosion resistance charts.
This bulletin is filled with valuable information on 18 materials that can be used to give you plant-wide protection from corrosion.

FOR YOUR COPY
WRITE TO

ATLAS MINERAL PRODUCTS COMPANY
MERTZTOWN, PENNSYLVANIA

TECHNICAL REPRESENTATIVES THROUGHOUT THE UNITED STATES

For more information, turn to Reader Service Card, Circle No. 462

CONTENTS NOTED

BOOKS

Safety in Industry. *D. I. Macfarlane. Philosophical Library, New York, N. Y. 1955. Cloth 6 by 9 in. 71 pp. Price $6.00.*

This is a general introduction to the subject of protection of workers from disease and accidents, giving details of a number of methods of improving working conditions. Subjects included are dangers of rotating machinery, control of dust and fumes, modern protective clothing, good lighting, eye protection and harmful radiation from radioactive substances.

REPORTS

Aluminum fatigue CUMULATIVE FATIGUE DAMAGE OF AXIALLY LOADED ALCLAD 75S-T6 AND ALCLAD 24S-T3 ALUMINUM-ALLOY SHEET. *Ira Smith, Darnley M. Howard, and Frank C. Smith, National Bureau of Standards. Sept. 1955. 49 pp, diagrams, photos. 5 tables. Available from National Advisory Committee for Aeronautics, 1512 "H" St., N.W., Washington 25, D.C.*

NACA TN 3293

Results are presented of cumulative-fatigue-damage tests made on 607 specimens machined from alclad 7075-T6 aluminum-alloy sheet 0.064 in. thick, and 198 specimens of alclad 2024-T3 and alclad 7075-T6 aluminum-alloy sheet 0.32 in. thick. The tests of the 0.064 in. thick specimens consisted of 35 different loading conditions and the tests of the 0.032 in. material consisted of 13 different loading conditions.

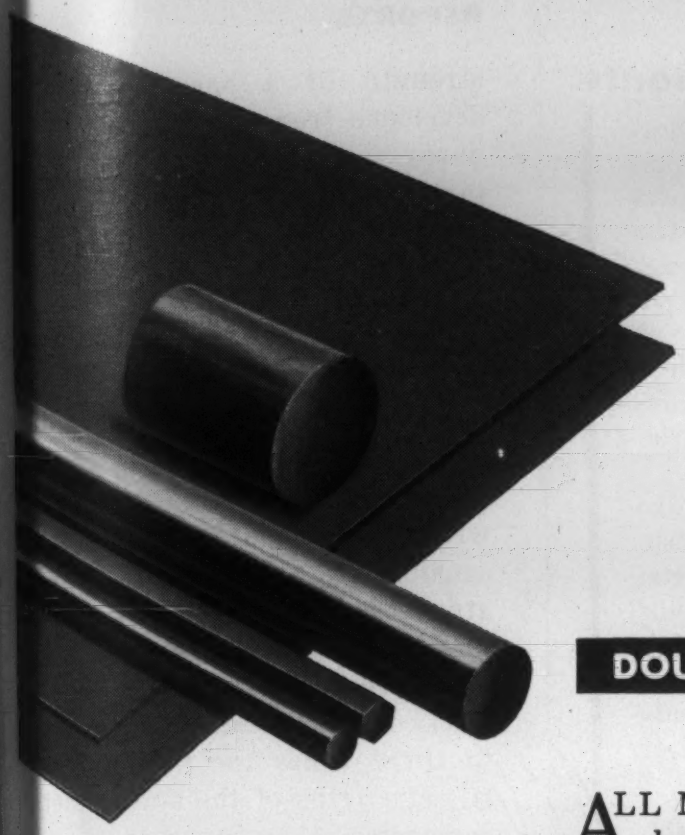
Porous metals WIRE CLOTH AS POROUS MATERIAL FOR TRANSPIRATION-COOLED WALLS. *E. R. G. Eckert, Martin R. Kinsler, and Reeves P. Cochran. Nov. 1951. 38 pp, diagrams, photos, tables. (Declassified from Confidential, 9/15/55). Available from National Advisory Committee for Aeronautics, 1512 "H" St., N.W., Washington 25, D.C.*

NACA RM E51H23

Investigation of the permeability characteristics and tensile

TITANIUM

for the full range of mill products call Mallory-Sharon



MST GRADE III—This material is commercially pure titanium. It is essentially all alpha titanium and is therefore not hardenable by heat treatment. It is more ductile than any commercial titanium alloy and is weldable. MST Grade III is available as 50,000 psi, 65,000 psi, or 80,000 psi yield strength material.

MST 6Al-4V—A heat-treatable alpha-beta bar and sheet alloy. The Al-V system is of the beta isomorphous type, showing no eutectoid decomposition. This alloy has excellent elevated temperature properties up to approximately 750°F. MST 6Al-4V is relatively insensitive to notches and is weldable.

MST 3Al-5Cr—A heat-treatable alpha-beta bar and forging alloy which is primarily used in the annealed condition. MST 3Al-5Cr has good elevated temperature properties.

MST 4Al-4Mn—A heat-treatable alpha-beta bar and forging alloy which is primarily used in the annealed condition. It has good elevated temperature properties. Eutectoid decomposition is so sluggish that it never occurs in commercial applications.

MST 8 Mn—An alpha-beta sheet alloy used primarily in the annealed condition. It has good formability and may be used at moderately elevated temperatures in the annealed condition. Eutectoid decomposition is so sluggish that it does not occur in commercial applications.

DOUBLE-MELTED TITANIUM AND TITANIUM ALLOYS

ALL Mallory-Sharon titanium is produced by "Method S" vacuum double melting, resulting in good machineability and forming characteristics. This process eliminates alloy segregation and enables carbon and gaseous contaminants to be held within very low limits. Likewise, Mallory-Sharon's patented rolling method and other technical advances assure you of the highest quality and uniformity.

Call us for the full range of titanium and titanium alloy mill products: rod, bar, sheet, strip, plate, etc. Our technical service group is equipped to give you the latest recommendations on forming, welding, and machining. For complete information write Mallory-Sharon Titanium Corporation, Dept. G-1, Niles, Ohio.

TYPICAL MECHANICAL PROPERTIES

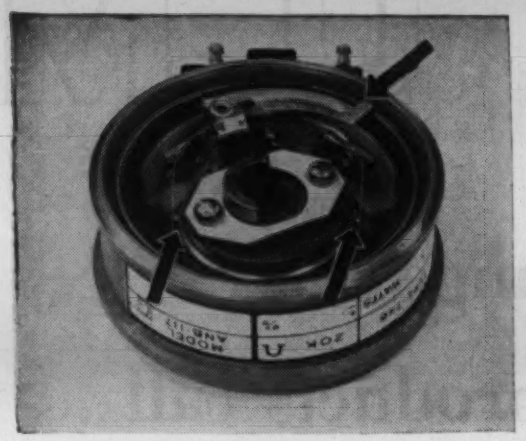
	Form	Ultimate Tensile Strength, psi	Yield Strength, psi	Elongation % in 2″
MST Grade III (Unalloyed) . .	Sheet, Bar	70,000	50,000	25
(3 different strength levels) .	Sheet, Bar	85,000	65,000	23
	Sheet, Bar	100,000	80,000	20
MST 6Al-4V (1)*.	Bar	149,000	137,000	13
(2)	Bar	164,000	153,000	13
(3)	Bar	198,000	180,000	9
(4)	Sheet	130,000	120,000	10
MST 3Al-5Cr	Bar	155,000	145,000	13
MST 4Al-4Mn	Bar	150,000	140,000	14
MST 8 Mn	Sheet	140,000	125,000	16

* (1) 1500—½—AC (3) 1700—½—WQ, 900-2-AC
(2) 1400—½—WQ, 1100-8-AC (4) 1450— 2—FC to 1100-AC

MALLORY Ti SHARON

For more information, turn to Reader Service Card, Circle No. 457

For more information, turn to Reader Service Card, Circle No. 385



Arrows point to Paliney #7 contacts used in this Fairchild Type 746 Precision Potentiometer.

NEY'S small parts play a BIG part in precision instruments

Reliability of many precision electrical instruments depends upon accurate transmission of electrical signals between moving parts. The Potentiometer Division of the Fairchild Camera and Instrument Corporation has selected Ney Paliney #7* for use as wipers and sliders in their precision potentiometers because Paliney #7 provides the important advantages of a long life with excellent linearity and the ability to hold noise at a minimum.

Ney manufactures many other precious metal alloys which, like Paliney #7, have ideal electrical characteristics, high resistance to tarnish, and are unaffected by most industrial atmospheres. Ney Precious Metal Alloys have been fabricated into slip rings, wipers, brushes, commutator segments, contacts, and intricate component parts and are used in high precision instruments throughout industry. Should you have a contact problem, a call to the Ney Engineering Department will result in study and recommendations which will improve the output of your electrical or electronic instruments.

THE J. M. NEY COMPANY • 105 ELM ST., HARTFORD 1, CONN.

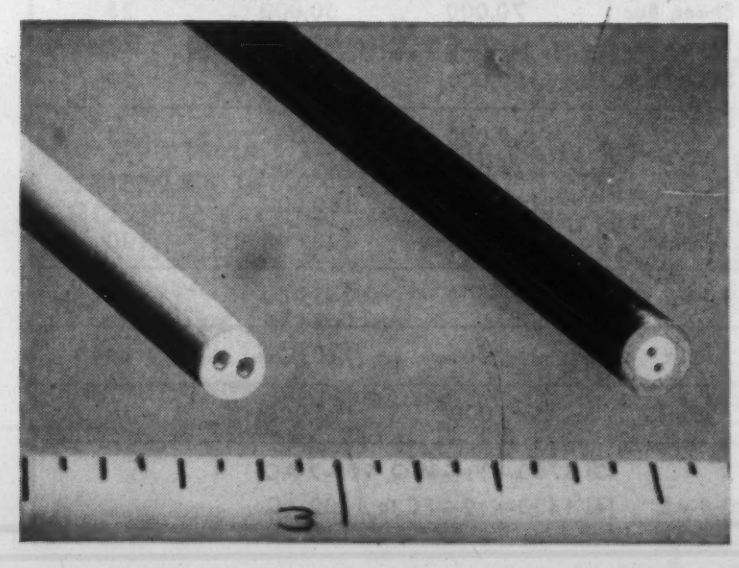
Specialists in Precious Metal Metallurgy Since 1812

*Registered Trade Mark

9NY55B

McDANEL

CRUSHABLE ALUMINA INSULATION FOR SWAGED THERMOCOUPLE TUBING



● **McDanel Crushable Alumina Insulating Tubing** crushes readily, packs firmly and uniformly without damaging conducting wire. Quickly strung and assembled. Competitively priced! Available for standard wire gauges in single, double and multiple bores. 1" to 6" length. Special shapes, sizes and bores available.

Write for samples and prices TODAY!

McDANEL Industrial CERAMICS

McDANEL

REFRACTORY PORCELAIN COMPANY

BEAVER FALLS • • • PENNSYLVANIA

For more information, turn to Reader Service Card, Circle No. 426

CONTENTS NOTED

REPORTS

strength of a porous material developed from stainless-steel corduroy wire cloth for use in transpiration-cooled walls where the primary stresses are in one direction. The results of this investigation are presented and compared with similar results obtained with porous sintered metal compacts. A much wider range of permeabilities is obtainable with the wire cloth than with the porous metal compacts considered; the ultimate tensile strength in the direction of primary stresses for porous materials produced from three mesh sizes of wire cloth is from two to three times the ultimate tensile strengths of the porous metal compacts.

Coatings for plastics DEVELOPMENT OF ELECTRICALLY CONDUCTIVE TRANSPARENT COATINGS FOR ACRYLIC PLASTIC. *John Bjorksten, Harry L. Hamilton, Evelyn E. Smith, and Robert J. Roth. Bjorksten Research Laboratories, Inc., Madison, Wis. Dec. 1952. 72 pp. photos, diagrams, graph, tables. Available from Library of Congress, Photoduplication Service, Publications Board Project, Washington, D.C. Mi $4.50, ph $12.50* PB 118034

In order to dissipate precipitation electrostatic charge built up on transparent plastic aircraft canopies during flight an electrically conductive transparent coating, easily applied to formed aircraft canopies made from acrylic sheet conforming to Specification MIL-P-5425, has been developed. The coating is applied by abrading or scratching the acrylic surface slightly with a suede brush, rubbing in finely divided graphite, and spraying the surface with a protective film of a 1:5 methacrylic acid-methyl methacrylate copolymer resin.

Titanium EFFECT OF MICROSTRUCTURE ON THE MECHANICAL PROPERTIES OF TITANIUM ALLOYS. Summary report covering the Period from June 18, 1951 through Dec. 31, 1953, under Contract no. DA

SUPERIOR PARTS AT LOWER COST

with Hunter Douglas Aluminum Cold Forgings

Hunter Douglas One-Piece Aluminum Cold Forgings are important to every designer and manufacturer as a means of *simplifying design, reducing cost* or *producing stronger, better products!*

Hunter Douglas cold forgings and impact extrusions offer these advantages:

TUBULAR SHAPES, open or closed ends.

ZERO DRAFT in all hollow parts; reduces metal waste and machine time.

HIGH STRENGTHS obtainable with wide alloy selection.

DENSE METAL STRUCTURE "porosity-free," withstanding high pressures in hydraulic or pneumatic applications.

SMOOTH SURFACE FINISH (typically 63 rms. as forged).

CLOSE TOLERANCES meeting all commercial requirements.

ONE-PIECE CONSTRUCTION replaces multi-piece assemblies and costly fabrications.

The typical examples above show how designers have utilized Hunter Douglas Aluminum Cold Forgings to provide a better solution to production problems, with resulting design simplification and cost savings.

If your component requirements offer potential quantities of 10,000 or more per month, ask our engineering department for an analysis. A blueprint or sample part will facilitate our recommendation.

1. LATCH BARREL *Originally made as a multi-piece assembly of several stampings . . . now instantly produced as a one-piece Hunter Douglas Aluminum Impact Extrusion requiring no assembly time. Metal grain flow connects flange with tube in continuous, unbroken lines. Strength equalled the original latch barrel design.*

2. ORDNANCE COMPONENT *Formerly made as a three piece assembly with a critical gas leakage problem . . . solved with this one-piece Hunter Douglas Aluminum Alloy Cold Forging. Highly stressed, it withstands bursting pressures of 5500 psi without distortion . . . was actually produced with less metal than was formerly machined away as chips.*

3. HYDRAULIC PLUNGER TUBE *Originally a welded assembly of several steel parts, now cold-forged in one piece. Zero draft plus close tolerance eliminated all boring and turning operations. Machine time, assembly time and metal waste greatly reduced. Fine, porosity-free grain structure produced by cold forging, combined with the proper, heat-treatable aluminum alloy easily satisfies strength requirements of this highly stressed part.*

4. VALVE BODY *The pre-requisites of high strength and porosity-free metal structure made this part a "natural" for Hunter Douglas Aluminum Cold Forgings. Zero draft on all surfaces simplified chucking. The solid cold forging produced the long stem and four studs. Accuracy and detail produced by cold forging reduced subsequent machining to drilling and tapping.*

DESIGNERS:

If you want to know more about Hunter Douglas Cold Forgings write on your letterhead for this free 40 page book, just off the press!

Hunter Douglas Corporation

HUNTER DOUGLAS CORPORATION, DEPT. MM-1, RIVERSIDE, CALIFORNIA TELEPHONE OVerland 3-3030

CONTENTS NOTED

REPORTS

33-019-ORD-280, Project TB 4-15. *F. C. Holden, H. R. Ogden, and R. I. Jaffe. Battelle Memorial Institute, Columbus, Ohio. Dec. 1953. 41 pp. photos, graphs. Available from Office of Technical Services, U.S. Dept. of Commerce, Washington, D.C. $1.25.* PB 111681

Summaries are presented of various phases of work conducted in a systematic investigation of the microstructure, heat treatment, and mechanical properties of titanium alloys prepared with high-purity iodide titanium. The Ti-Cu alloys are quench hardenable and have been found to be similar to steels in their response to heat treatment and microstructure variations.

SCALING OF TITANIUM AND TITANIUM ALLOYS. *H. W. Maynor, Jr., B. R. Barrett, and R. E. Swift. Kentucky University Dept. of Mining and Metallurgical Engineering. Mar. 1955. 137 pp. photos, drawing, graphs, tables. Available from Office of Technical Services, U.S. Dept. of Commerce, Washington, D.C. $3.50* PB 111731

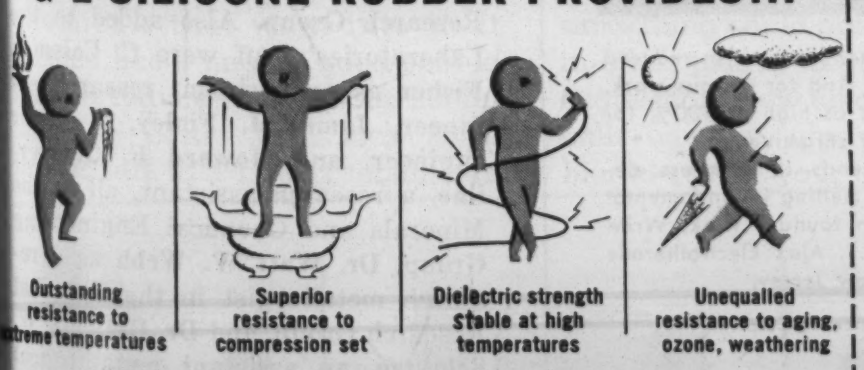
A preliminary study of the scaling characteristics in air of experimentally produced titanium and titanium-base alloys, and commercially produced titanium and titanium-base alloys was conducted at temperatures of 1200, 1400, 1600, and 1800 F in the time range of approximately four to three hundred hours. A total of 43 titanium-base alloys, one commercial grade of titanium (RS-70), and type 302 stainless steel were scaled at each of these temperatures; two additional alloys were employed at temperatures of 1200 and 1600 F. Scales formed on a 4.02% Al-Ti alloy were studied in detail and a scaling mechanism was suggested; scales formed on a 4.03% Cr-Ti alloy and a 2.95% W-Ti alloy were studied in less detail. Scaling propensity of titanium-base alloys, relative to titanium and stainless steel, was evaluated on the basis of weight gain with time.

How can you benefit from the AMAZING "COME-BACK" of G-E SILICONE RUBBER?

Amazing recovery from compression is one of the most useful characteristics of General Electric silicone rubber. In fact, Class 300 silicone rubber has more "come-back" over a wider temperature range than any known rubber! That's why designers now use it where compression is a factor. They know that O-rings and gaskets made of Class 300 silicone rubber *resist compression set*—give *more positive* sealing action for better performance!

Where can YOU use G-E silicone rubber? There's a kind for almost every requirement, classified according to dominant property for easy selection and specification. For example: Class 500 offers flexibility *at 120 F below zero!* Class 700 provides serviceability *up to 600 F!* Which class of G-E silicone rubber is best for *you?*

G-E SILICONE RUBBER PROVIDES...



G-E silicones fit in your future

GENERAL ELECTRIC

SEND FOR A FREE "LIGHTNING SELECTOR"—TODAY!

Silicone Products Department
General Electric Company
Section 61-1E
Waterford, New York

Please send me technical data on G-E silicone rubber, including a free "Lightning Selector" and up-to-date list of fabricators. I am chiefly interested in:

1 ( ) Molded gaskets, bushings
2 ( ) O-rings
4 ( ) Shock mounts
12 ( ) Rubber bonded to metal
13 ( ) Die-cut gaskets
Other_____

Name_____ Position_____

Firm_____

Street_____

City_____ Zone___ State_____

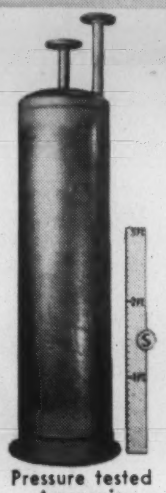
IN CANADA: Mail to Canadian General Electric Company, Ltd., Toronto

For more information, turn to Reader Service Card, Circle No. 399

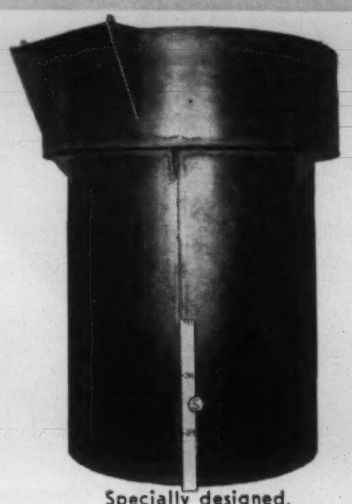
For more information, turn to Reader Service Card, Circle No. 383

SPECIAL ALLOYS plus EXPERIENCED TECHNICIANS Assure WELDMENTS by STANWOOD that can "live with heat".

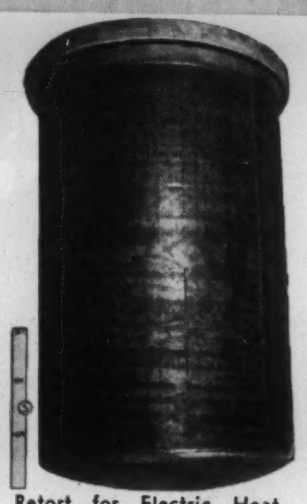
While we have made fabrications and weldments a few inches in diameter, the big, bulky, fussy, intricate jobs, which some shy away from, are our meat. These jobs are typical . . . correct metals used for the particular job involved . . . skillful, smooth fabricating . . . sound, gastight welds throughout. We do it every day . . . we'd like to do it for you. Send for literature.



Pressure tested Ammonia Dissociator.



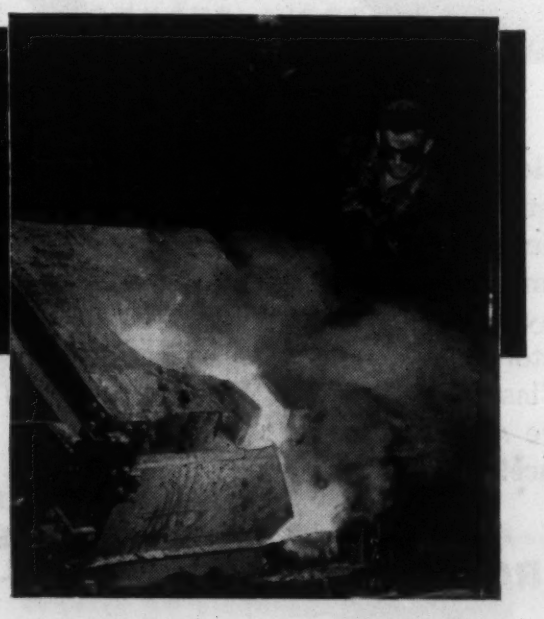
Specially designed, pit type, quenching tank.



Retort for Electric Heat Treating Furnace.

Stanwood Corporation
HEAT TREATING EQUIPMENT
4813 W. CORTLAND ST. CHICAGO 39, ILLINOIS

600 lbs. OF BRONZE melted in 23 minutes



This steel and non-ferrous centrifugal-casting foundry saves more than time through the use of Ajax-Northrup induction furnaces. Freedom from contamination and almost complete metal recovery are direct results of the high speed characteristic of the Ajax-Northrup melting principle. Electrical energy, used as the source of power, is expended almost entirely in the charge. Little is wasted on the refractory lining or outside the furnace, thereby making working conditions better and more efficient at the same time.

Many Ajax-Northrup furnaces are made to accept either ferrous or non-ferrous work . . . with impressive savings for both. With non-ferrous alloys, savings of over $33.00 a ton are reported in reduced metal losses alone. And for ferrous work, recovery is reported as high as 100% for nickel and 99% for chromium.

Economy recommends it, progress demands it; induction melting is fundamental to modern precision foundry work. Write for Bulletin 27-B . . . Ajax Electrothermic Corp., Trenton 5, New Jersey.

Associated Companies: Ajax Electric Company—Ajax Electric Furnace Co.—Ajax Engineering Corp.

AJAX NORTHRUP SINCE 1916

INDUCTION HEATING-MELTING

For more information, turn to Reader Service Card, Circle No. 365

NEWS OF ENGINEERS COMPANIES SOCIETIES

NEWS OF ENGINEERS

Harold Etherington and **William Jackel** have been made vice presidents of The Nuclear Energy Products Div., ACF Industries, Inc.

George R. Milne has been appointed president, National Carbide Co., a division of Air Reduction Co., Inc.

Dr. Maurice H. Bigelow has been given the newly-created position of director of research, Research and Development Department, Barrett Div., Allied Chemical & Dye Corp. Other new appointments in the same department include **David E. Cordier** as director of the Glendale Plaskon Laboratory, and **James B. Maguire**, director of development.

G. W. Reese, formerly vice president in charge of American Can Co.'s Atlantic Div., has been named vice president in charge of manufacturing for the entire company.

Arthur M. Swigert has been made works manager of the newly-acquired Detroit Universal Div., Chrysler Corp.

Howard C. Jones has been given the new position of director of manufacturing, Consolidated Vacuum Div., Consolidated Electrodynamics Corp.

Earl M. Douglas has been named vice president, Dana Corp.

Dr. Cyril J. Staud has been elected vice-president in charge of research, Eastman Kodak Co. He succeeds Dr. **C. E. Kenneth Mees**, who has retired.

Dr. Thomas A. Henrie has recently joined Electro Metallurgical Co.'s Metals Research Laboratories as a research chemist in the Chemicals Research Group. Also added to the Laboratories' staff were **C. Coleman Fisher** as an assistant research engineer, **James J. Finley**, a junior engineer, and **Howard F. Gemperline**, a research assistant, all in the Minerals and Chemical Engineering Group, **Dr. Watt W. Webb** as a research metallurgist in the Chemical Research Group, and **Dr. Helmuth W. Schultze**, an assistant metallurgical engineer in the Technical Services and Development Laboratory.

Dr. Nat C. Robertson has been appointed director of research, Escambia Bay Chemical Corp.

(Continued on p. 202)

Flabbergasted!

"Yes sir, that's what I was—flabbergasted! Never dreamed that we had so much of our production investment tied-up in metal cleaning and surface preparation operations. What started the whole thing off was when the Detrex man pointed out to me that in the average metal working plant ¼ to ⅓ of all the operations are metal cleaning or surface preparation. I could hardly believe it at first, but when I checked our plant—sure enough, 30% of all our operations were of that nature.

"Naturally I began to pay a little more attention to that phase of our operation and the equipment and chemicals that went into it. It seemed like a mighty good spot to try and reduce some of our manufacturing costs. So I took some time to talk to a Detrex technician and, after he had studied our operation, he came up with some down-to-earth recommendations that really made sense. I was quite surprised to learn how extensive their line of equipment is. They have all kinds and sizes of degreasers, washers and sonic cleaners. In fact, whatever you want to do in the way of metal cleaning or surface preparation, they've got the equipment to do it. And they make the chemicals, too!

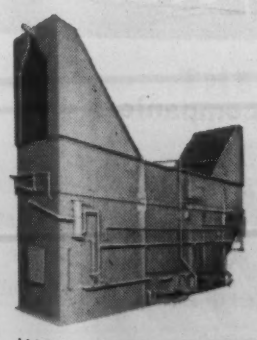
"As a result of the survey of our plant and the recommendations Detrex made, we've realized some important reductions in our manufacturing costs. I feel sure that the same thing could probably be done in other plants, too. So I'll make a suggestion. Next time a Detrex man calls on you, why don't you ask him to survey your operations? He isn't going to charge you anything for that service and chances are you'll realize some savings, too. If you're like me, you probably didn't know that you could get such a survey without a cash outlay. Well you can, and the Detrex technicians are real experts in their line. When they make a survey it's factual and the recommendations are sound. You'll find, like I did, that it's time well spent."

Service with a Saving!

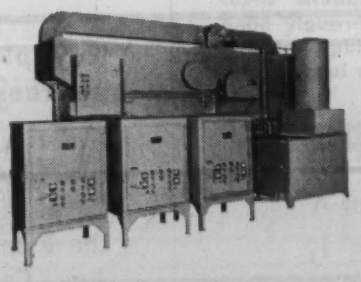
DETREX CORP.

Dept. 510 • Box 501, Detroit 32, Mich.

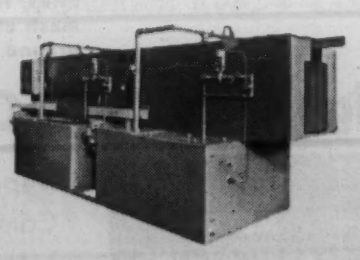
DEGREASERS • DEGREASING SOLVENTS • WASHERS ALKALI & EMULSION CLEANERS • DRYCLEANING EQUIPMENT • PHOSPHATE COATING PROCESSES



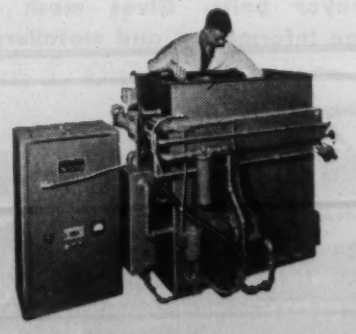
VAPOR-SPRAY-VAPOR DEGREASER



CROSSROD CONVEYORIZED SONICLEAN® DEGREASER

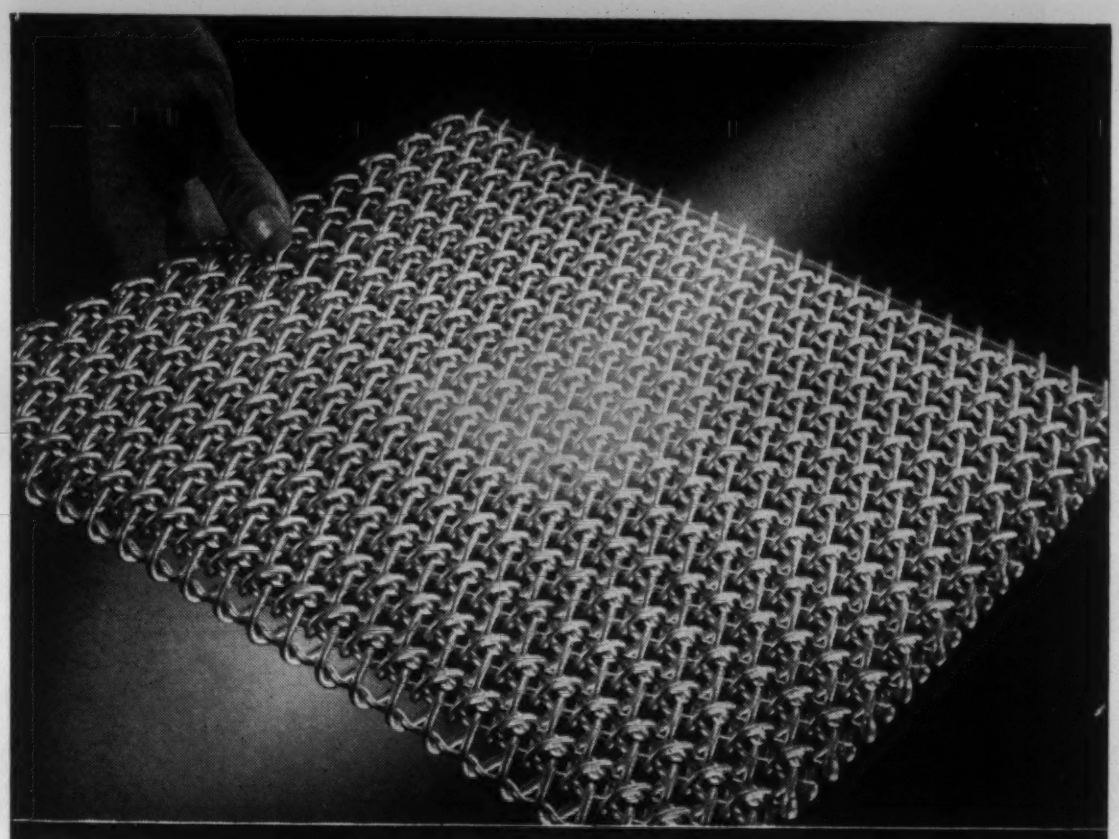


CONVEYORIZED MULTI-STAGE WASHER



MANUAL OPERATED SONICLEAN® DEGREASER

For more information, turn to Reader Service Card, Circle No. 327



FREE CIRCULATION!

means continuous low-cost heat treating with *Cambridge* WOVEN WIRE CONVEYOR BELTS

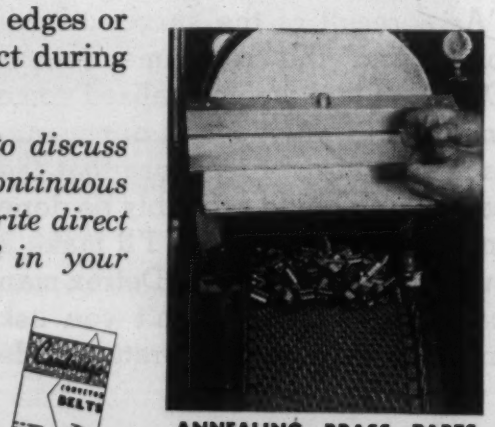
Open mesh construction lets heat and gases circulate freely all around the work for uniform annealing, brazing, sintering at controlled rates of speed. Moving belt eliminates batch handling, cuts costs, provides continuous production.

All-metal Cambridge Woven Wire Conveyor Belts are impervious to damage from constant operation at temperatures up to 2100° F . . . have no seams, lacers or fasteners to wear more rapidly than the body of the belt, no localized weakening. Open mesh also permits free drainage of process solutions in quenching, pickling and tempering.

No matter how you look at it, CAMBRIDGE Woven Wire Conveyor Belts are invaluable aids to AUTOMATION . . . eliminate profit-stealing batch and hand operations. They are made in any size, mesh or weave, and from any metal or alloy. Special raised edges or cross-mounted flights to hold your product during movement are available.

Call in your Cambridge Field Engineer to discuss how you can cut heat treating costs by continuous operation. You can rely on his advice. Write direct or look under "BELTING, Mechanical" in your classified telephone book.

WRITE TODAY FOR FREE 130-PAGE REFERENCE MANUAL illustrating and describing woven wire conveyor belts. Gives mesh specifications, design information and metallurgical data.



ANNEALING BRASS PARTS Process atmosphere circulates freely through open mesh of Cambridge belt and around small or large parts.

The Cambridge Wire Cloth Company

WIRE CLOTH | METAL CONVEYOR BELTS | SPECIAL METAL FABRICATIONS

Department A
Cambridge 1, Maryland

OFFICES IN PRINCIPAL INDUSTRIAL CITIES

For more information, turn to Reader Service Card, Circle No. 318

news of | ENGINEERS

George A. Cypher has been promoted to specialist—insulating materials for General Electric Co.'s Chemical Materials Department. In addition, the company has advanced **James F. Whitney** to superintendent of the Phenolic Products Plant.

Dr. Robert W. Cairns has been selected as director of research, Hercules Powder Co.

Lester E. Johnson has joined The International Nickel Co., Inc., as supervisor of the Industrial Chemicals Section, Development and Research Div. **Edward P. Sadowski** has joined the same division as a research metallurgist in the Iron Alloys Section of the Research Laboratory.

Jack J. Carlson has been appointed a vice president, Kaiser Steel Corp., and general manager of the Montebello, Calif., Fabricating Div. plant. **B. J. Osborne**, formerly general manager of the plant, has moved to the Oakland home offices of the company as assistant to the vice president and general manager for consultation in connection with Kaiser Steel's Fabricating Div. operations.

David C. Ekey has been made director of research, Lebanon Steel Foundry.

Daniel J. Girardi has been advanced to the post of metallurgical engineer in charge of Research and Process Control, The Timken Roller Bearing Co.

Edgar W. Engle has been made technical director, Vascoloy-Ramet Corp.

William C. Osborne has been promoted to manager of engineering, Harrison Div., Worthington Corp., and **Everett C. Schmachtenberg**, assistant to the manager of engineering.

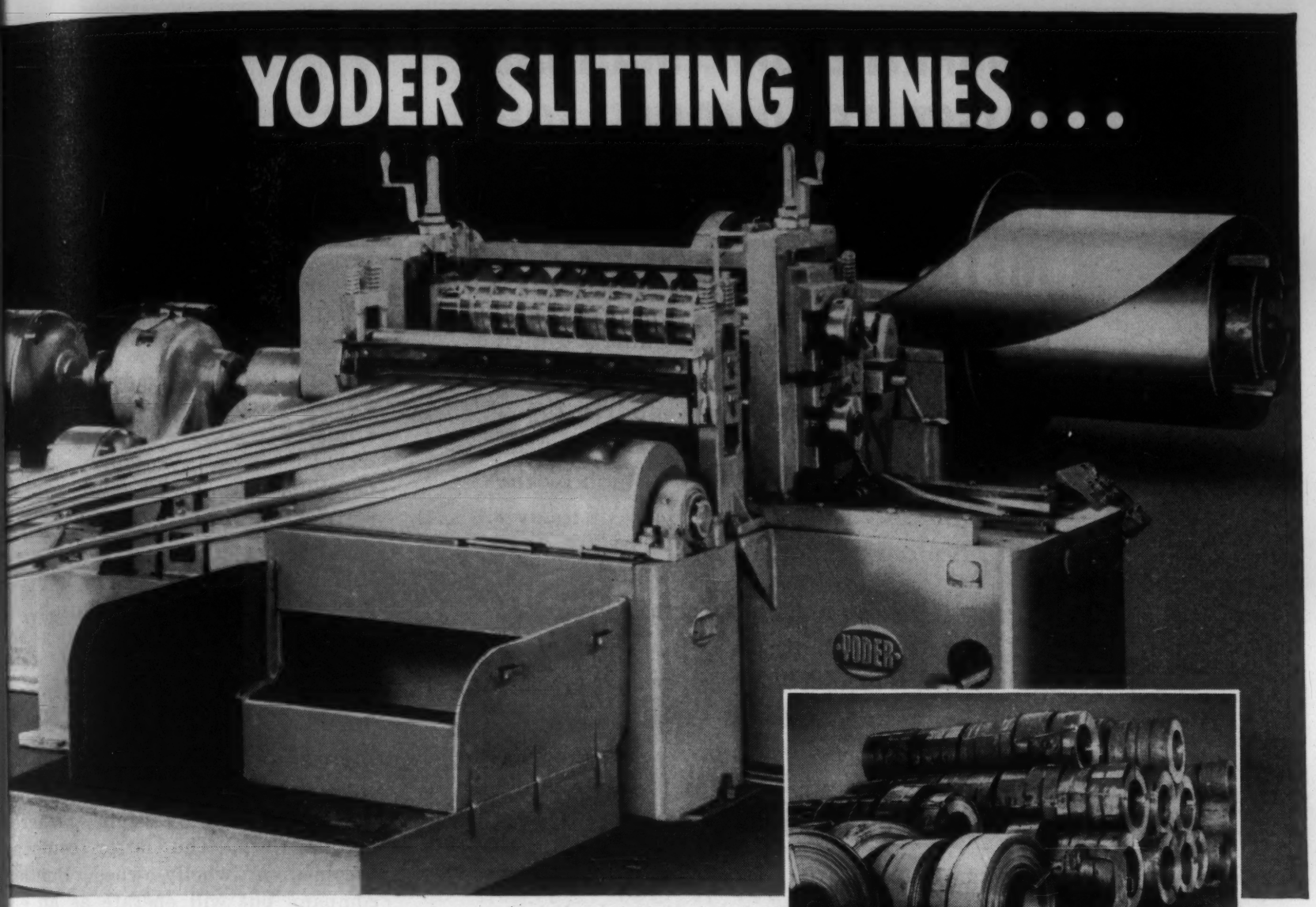
news of | COMPANIES

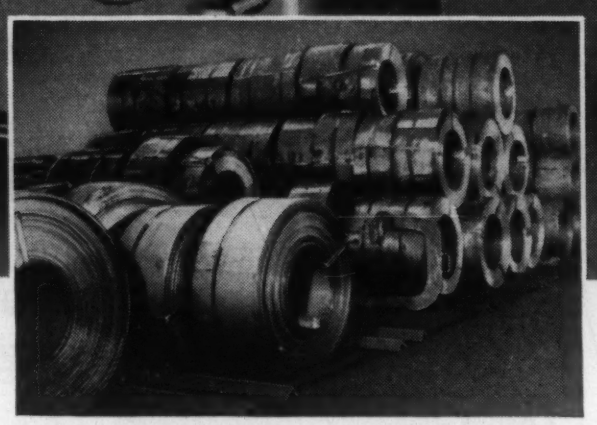
New plants, companies, addresses

American Agile Corp. has announced the formation of the Agile Plastic Corp. of Calif., with headquarters in the First Western Bank Bldg., Santa Ana, Calif.

(Continued on p. 204)

YODER SLITTING LINES...





Standardized Series for LOW FIRST COST AND OPERATING COST!

A relatively small, low-cost Yoder slitting line offers attractive savings possibilities and high production in slitting small and medium coil sizes and strip gauges. Yoder has standardized a series of such machines, affording a rare combination of low cost and productive capacity amply sufficient for the needs of the great majority of sheet metal fabricators and custom slitting shops. Supplementing the standardized series are *special models for slitting big coils and heavy gauges at high speeds.*

For requirements as low as 100 tons per month, one of the standardized Yoder slitting lines will pay for itself in short order. The savings PER TON increase rapidly with decrease in coil size and width of strands to be slit.

Another important advantage gained by fabricators having their own slitter is the ability, from a relatively small stock of standard width coils, to meet expected and unexpected needs for slit strands in a few hours. This means easier production planning and greatly reduced strip inventories, in addition to lower prices and quicker deliveries of their strip purchases.

Yoder Slitter Book contains basic information on the economics and mechanics of slitter operation, with time and cost studies, production records and other valuable data. Send for it.

THE YODER COMPANY • 5546 Walworth Ave. • Cleveland 2, Ohio

ENGINEERING YODER MANUFACTURING

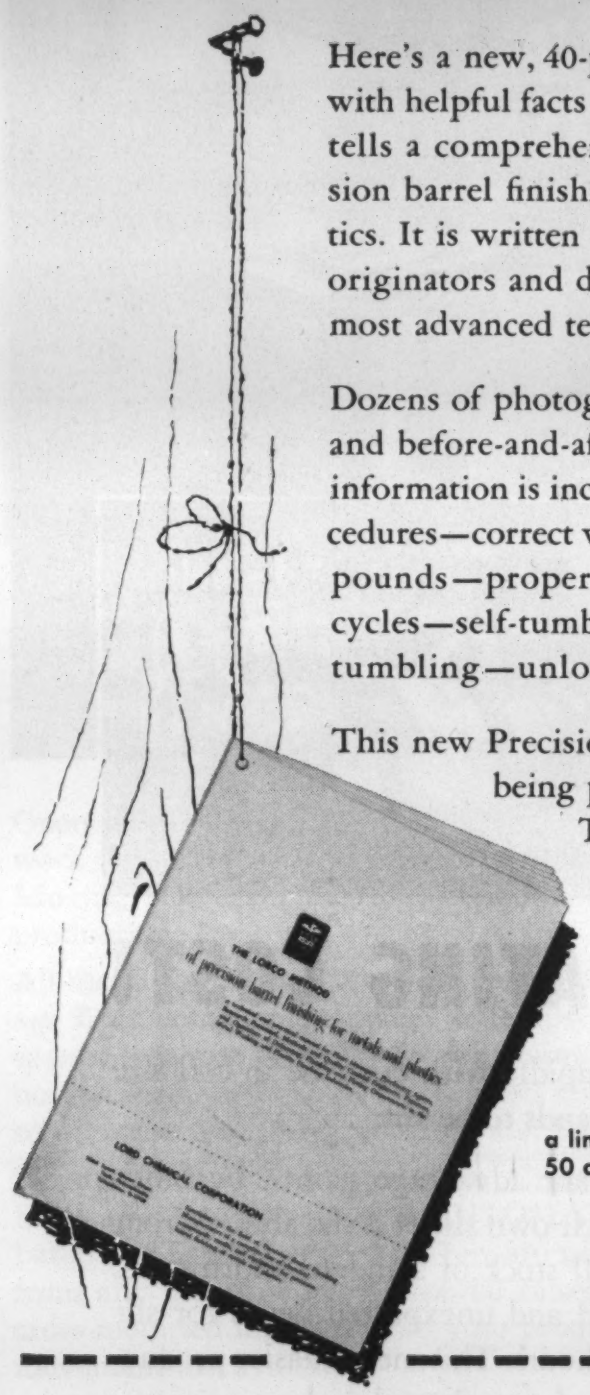
ROTARY SLITTING LINES

COLD ROLL FORMING MACHINES

ELECTRIC-WELD PIPE AND TUBE MILLS

For more information, turn to Reader Service Card, Circle No. 355

A NEW, COMPREHENSIVE MANUAL OF THE LATEST TECHNIQUES FOR PRECISION BARREL FINISHING METALS and PLASTICS



Here's a new, 40-page, practical guide . . . filled with helpful facts and processing data . . . which tells a comprehensive story of modern precision barrel finishing for both metals and plastics. It is written in step-by-step fashion by the originators and developers of many of today's most advanced techniques.

Dozens of photographs show actual operations and before-and-after parts. A fund of valuable information is included on: proper loading procedures—correct water levels—selection of compounds—proper media types and sizes—time cycles—self-tumbling—free tumbling—fixture tumbling—unloading and drying of parts.

This new Precision Barrel Finishing manual is being published as a limited edition. The price is 50 cents per copy. To obtain yours, please mail coupon below.

a limited edition . . .
50 cents per copy

LORD CHEMICAL CORPORATION

Dept. MM, 2068 S. Queen St.
York, Pennsylvania

Enclosed is $_____(amount) for_____(number) copies of the new Precision Barrel Finishing Manual.

Send them to:

Name_____

Company_____

Street_____

City_____ Zone____ State_____

For more information, turn to Reader Service Card, Circle No. 465

news of | COMPANIES

Bacon Felt Co. has opened a new 10,000 sq ft addition to its manufacturing facilities in Taunton, Mass. The new section houses equipment that will make possible a 20% increase in the production of the felt wheels, bobs and sheet felt manufactured by Bacon.

E. I. du Pont de Nemours and Co.'s Film Department has placed in operation a new sales development and technical service laboratory at Chestnut Run, near Wilmington, Del.

EPM Corp. has been formed for the manufacture of thermosetting plastic bobbins, coil forms, rod and many other custom fabricated insulating parts. Manufacturing facilities are located at 570B Van Siclen Ave., Brooklyn, N. Y., and general offices at 675 Barbey St., Brooklyn, N. Y.

Mergers, acquisitions

Bunting Brass & Bronze Co. has purchased **The Detroit Sintered Metals Corp.** The latter company becomes a wholly-owned Bunting company but will operate as an entirely separate company and will manufacture sintered metal parts and bearings as in the past.

Kelsey-Hayes Wheel Co. has completed a merger with **Steel Products Engineering Co.**

Standard Pressed Steel Co. and **Cleveland Cap Screw Co.** have agreed to combine. Neither company will change its name.

U. S. Industries, Inc., has acquired the assets of **Southern Pipe & Casing Co.** Southern Pipe has become a USI division.

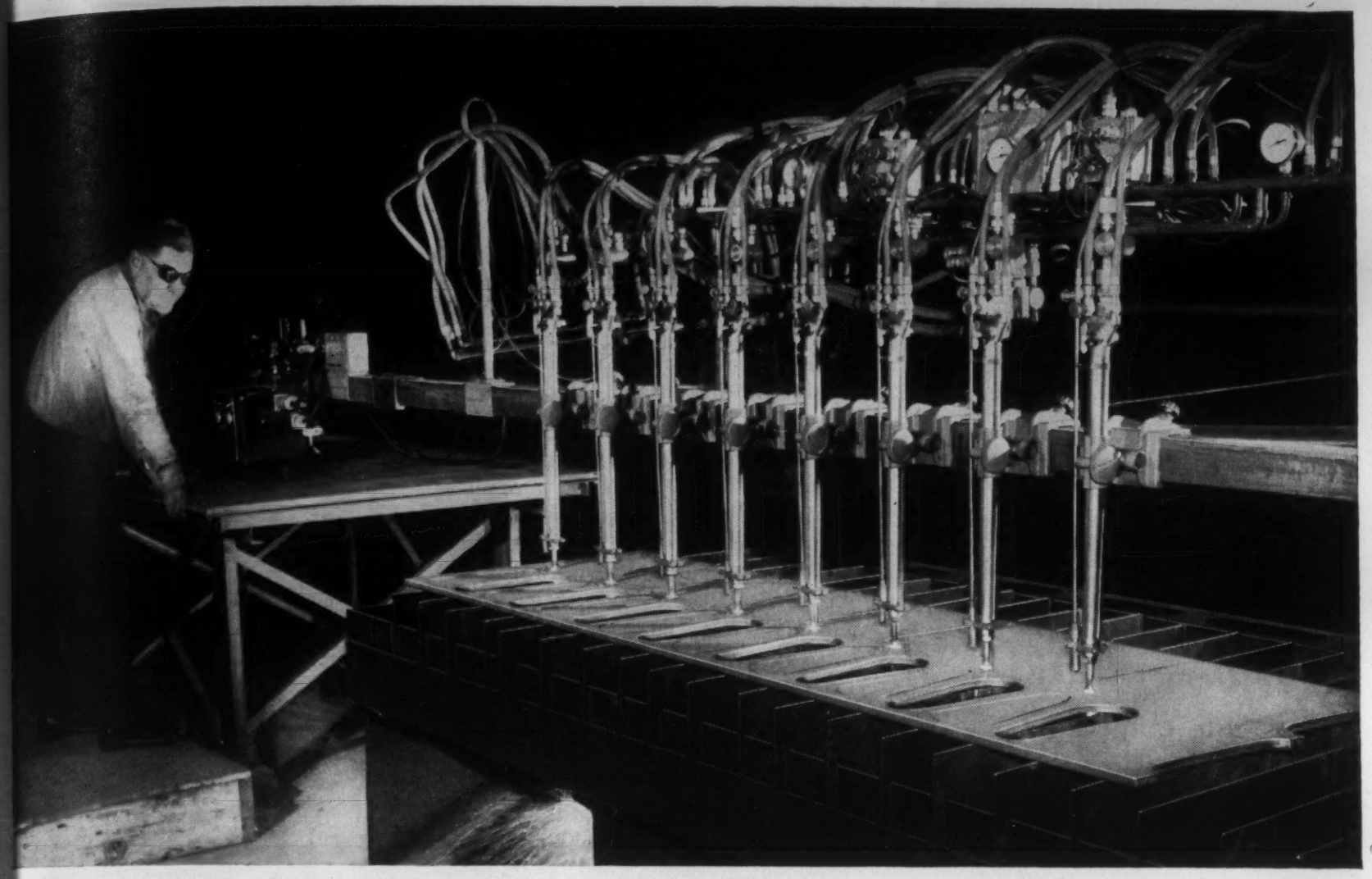
Expansions planned

Alan Wood Steel Co. has launched the second phase of its expansion program, involving an increase of 19% in steel making capacity and the expenditure of approximately $14,000,000 over the next two years.

Fansteel Metallurgical Corp. has authorized a tantalum-columbium production expansion program at an estimated cost of one million dollars.

Goodyear Tire and Rubber Co., as part of its $100,000,000 expansion program, has begun construction work on a $3,500,000 capacity increase to its Chemigum plant.

Inland Steel Co. has announced a three-year expansion program for its basic steel plant at East Chicago, Ind., that will lift its steel making



Many 'hands' make light work...

...with unerring accuracy

Smoothly, the oxyacetylene torch severs and shapes steel plate with unerring accuracy. This universally accepted method of separating metal—machine gas cutting—has advanced in giant steps since torch cutting was introduced. It is impossible to enumerate the many benefits that modern cutting and welding practices have given the metalworking industry. Inevitably even greater services shall be rendered.

Today's complex production requirements demand machines of extensive range and extreme versatility. Which is the *right* Airco shape cutting machine for you?

- **Airco #50 Travograph.** Track-mounted for unlimited range, this unit shape cuts up to eight identical parts within a full 12′ circle. The cutting torches conform exactly to the movement of an electronic, manual, magnetic, or spindle tracer.
- **Airco #6B Oxygraph.** (Illustrated) This stationary machine shape cuts within a 29′-9½″ x 6′-4½″ area. It operates on the pantograph principle (pioneered by Airco) mounting up to 8 torches.
- **Airco #48 Duograph.** Designed for the smaller metal fabricating shop, the Duograph has a rectangular cutting range of 4′ by any length.

Other Airco machine gas cutting units include the Monograph, Radiagraph, and new Camograph. Details on each are fully covered in individual bulletins. Write today.

AIRCO®

AIR REDUCTION SALES COMPANY

A division of Air Reduction Company, Incorporated, New York 17, N. Y.

Offices and dealers in most principal cities

On the west coast — Air Reduction Pacific Company

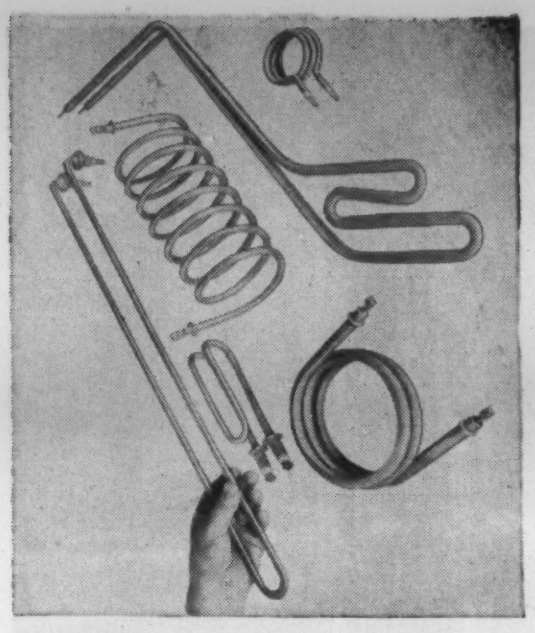
Internationally — Airco Company International

In Cuba — Cuban Air Products Corporation

In Canada — Air Reduction Canada Limited

Products of the divisions of Air Reduction Company, Incorporated, include: **AIRCO** — industrial gases, welding and cutting equipment, and acetylenic chemicals • **PURECO** — carbon dioxide, liquid-solid ("DRY-ICE") • **OHIO** — medical gases and hospital equipment • **NATIONAL CARBIDE** — pipeline acetylene and calcium carbide • **COLTON** — polyvinyl acetates, alcohols, and other synthetic resins.

For more information, turn to Reader Service Card, Circle No. 380



CHROMALOX
Electric
TUBULAR HEATERS

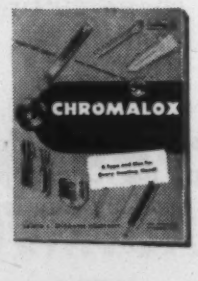
provide controlled and dependable conduction, convection or radiant heat

These versatile Chromalox Tubular Heaters provide the kind of heat you need, exactly fitted to your specific heating application.

Available in straight lengths or formed to any desired shape. Used for heating dies, molds, platens; as immersion heaters in liquids, soft metal and molten salts; or in ovens, air ducts and other air heating applications.

Let the Chromalox Sales Engineering staff solve your heating problems . . . electrically

Write for your copy of Catalog 50



—for full information on the complete line of Chromalox Electric Heaters and controls.

For ideas on additional applications of electric heat, request Booklet F1550—"101 Ways to Apply Electric Heat."

Edwin L. Wiegand Company
7523 Thomas Boulevard, Pittsburgh 8, Pennsylvania

EDWIN L. WIEGAND COMPAIIY
7523 Thomas Boulevard, Pittsburgh 8, Pa.

I would like to have . . .

☐ a copy of Catalog 50
☐ a copy of "101 Ways"
☐ a Sales Engineer contact me.

Name_____

Company_____

Street_____

City_____ Zone___ State_____

A-4466A

For more information, Circle No. 364

news of | COMPANIES

capacity 15% to 6,000,000 tons of ingots annually by 1959.

Awards

Allmetal Screw Products Co., Inc., has announced its sponsorship of an annual award, with $1000 as first prize, to be given to the author of the article of most value and interest to those who specify or buy stainless steel parts or components.

American Silver Co. has instituted a $1000 prize contest for engineers and designers for the best new applications of thin gage and/or high-precision tolerance stainless steel strip. Thirty-one separate cash awards will be made in the contest which closes midnight, May 30, 1956.

news of | SOCIETIES

The American Society of Mechanical Engineers has announced the election of Joseph W. Barker, chairman and president, Research Corp., as its president. The following regional vice-presidents were elected: Charles E. Crede, vice-president and chief engineer, Barry Controls Inc., Frank W. Miller, vice-president, Yarnall-Waring Co., Albert C. Pasini, general superintendent of production, The Detroit Edison Co., and Bryan T. McMinn, professor of mechanical engineering, University of Washington.

The Drop Forging Assn. has named Richard Marcus its new assistant secretary-treasurer.

The Association recently moved its headquarters to 419 S. Walnut St., Lansing, Mich.

The Gray Iron Founders' Society has re-elected C. H. Ker, president, The Dalton Foundries, Inc., as president. J. Scott Parrish, Jr., The Richmond Foundry and Manufacturing Co., Inc., was elected the new vice president. In the Society's 1955 Gray Iron Redesign Contest, first prizes went to B. W. Johnson and C. E. Day, Aquamatic, Inc., and second and third prizes to Frank K. Clifford, sales representative, Olney Foundry, Link-Belt Co., and William S. Thomas, vice president, Emmaus Foundry & Machine Co., respectively.

The Investment Casting Institute has elected V. S. Lazzara, president of Casting Engineers, Inc., as president. Elected as vice president of the Institute was R. S. Banister, Midwest Foundry Co.

(Meetings & Expositions on p. 208)

PYRO
Instruments for Precision Temperature Measurements

PYRO
Optical Pyrometer

Determines temperatures of minute spots, fast-moving objects and smallest streams—at a glance! No correction charts or accessories needed. Easy to use—weighs only 3 lbs. Special types available to show true spout and pouring temps of molten ferrous metal measured in open. Five stock ranges from 1400° F. to 7700° F. Write for FREE Catalog No. 85.

The Improved PYRO
Surface Pyrometer

The ideal instrument for all plant and laboratory surface and sub-surface temperature measurements. Available with large selection of thermocouples and extension arms for all jobs. Designed for ruggedness and accuracy . . . it features automatic cold end compensation, large 4½" direct reading dial and shock, moisture and dust-proofed shielded steel housing. 5 stock ranges 0-300°F. to 0-1200°F. Ask for catalog No. 168.

PYRO
Radiation Pyrometer

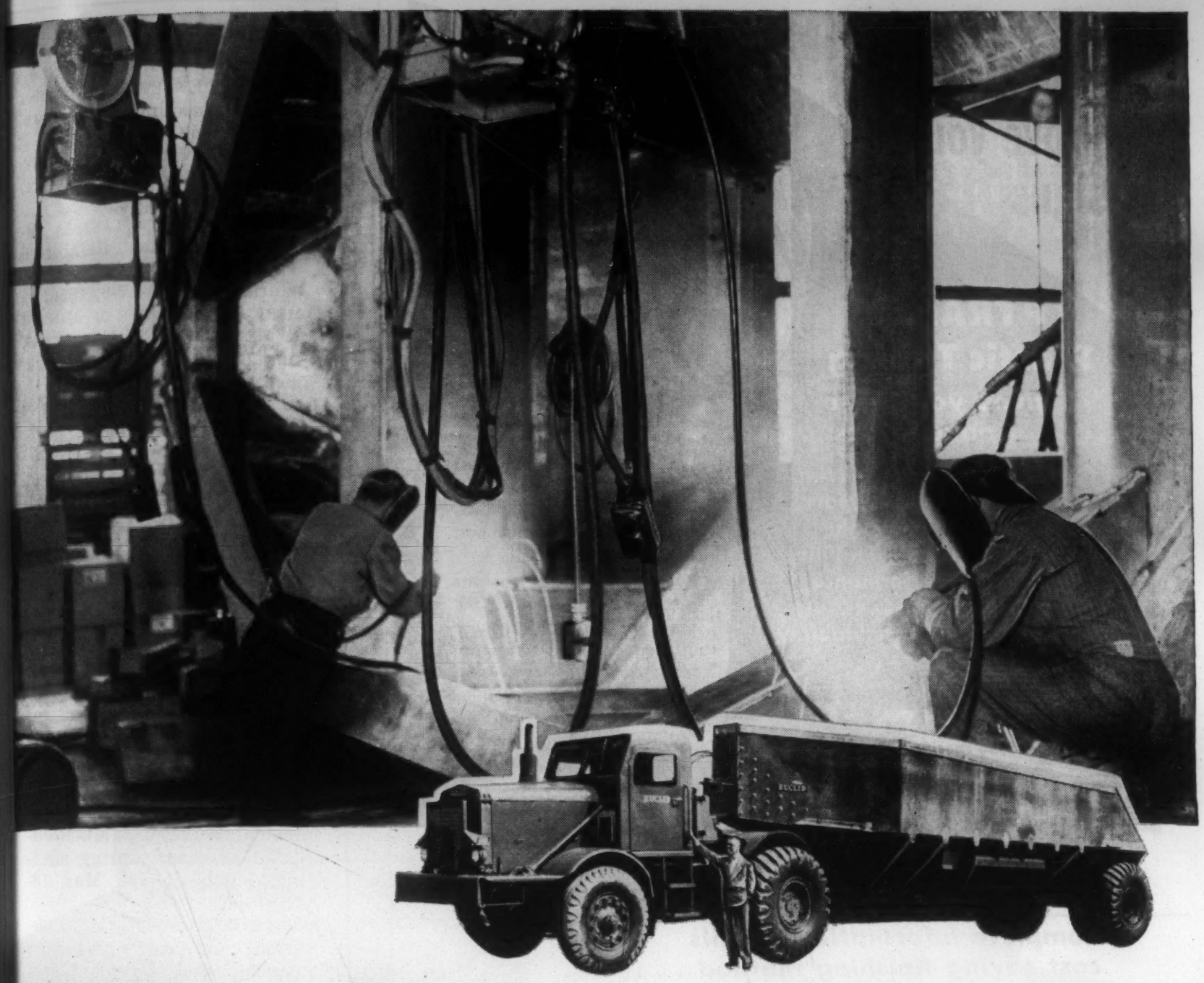
Tells spot temperatures instantly in heat-treating furnaces, kilns forgings and fire boxes. No thermocouples, lead wires or accessories needed! Temperature indicated on direct-reading dial at a press of the button. Any operator can use it. Two double-ranges from 1000° F. to 3400° F. Write for FREE Catalog No. 100.

PYRO
Immersion Pyrometer

The Pyro Immersion Pyrometer is shock proof, moisture proof, dust proof, immune to magnetic influences. Shielded steel housing. Instantly interchangeable thermocouples without adjustment or recalibration. Large 4" scale. Equipped with exclusive Lock Swivel. Ranges 0-1500 to 0-2500 F. Get FREE Catalogue No. 155.

The PYROMETER INSTRUMENT COMPANY
New Plant & Laboratory
BERGENFIELD 27, NEW JERSEY

For more information, Circle No. 368



33% Lighter...

Sigma Welding helps up truck pay-load 5 tons

The less weight consumed in a truck's structure, the more room there is for the all important pay-load. By sigma welding these giant drop-bottom dump trailers of sturdy aluminum alloy, 8,210 lb. dead-weight has been eliminated —and truck capacity increased 5 tons.

In this operation, sigma rod feed units are suspended above the work area to allow each operator complete freedom of movement with his sigma torch. Sigma welding operations are fast, and finished welds are of highest quality. The 36-ft. long trailers are fabricated of 5/16 and 5/8-in. plate, and 3/8 and 3/4-in. channel extrusions.

Like many other products throughout industry, these trailers are being fabricated with new quality and efficiency using sigma welding with argon shielding. Sigma welding produces smooth, high-quality welds in all type joints, and exceeds 100 in. per min. in many operations. It is an efficient method for joining such metals and alloys as carbon steel, stainless steel, copper, bronze, aluminum, and unalloyed titanium. Start saving now with greater production speed and unit quality—call your local LINDE representative today.

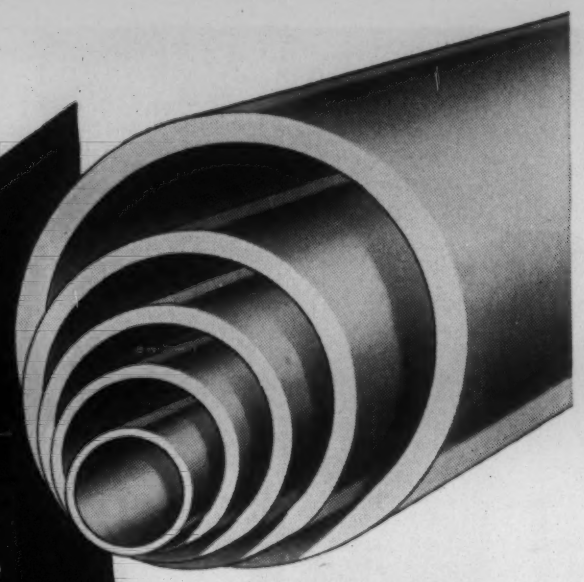
Linde Air Products Company
A Division of Union Carbide and Carbon Corporation
30 East 42nd Street UCC New York 17, N. Y.
Offices in Other Principal Cities
In Canada: LINDE AIR PRODUCTS COMPANY
(formerly Dominion Oxygen Company)
Division of Union Carbide Canada Limited, Toronto

The term "Linde" is a registered trade-mark of Union Carbide and Carbon Corporation.

Linde
Trade-Mark

For more information, turn to Reader Service Card, Circle No. 400

Simplify and improve your designs



PYRAMID Plastic Tubing

gives you these advantages . . . . . CUTS COST

- Easier to Work With
- Requires Less Space
- Lighter in Weight
- Dimensional Stability
- Better Performance
- Longer Life
- Greater Dependability

We manufacture tubing as small as .020 I.D. with .015 wall from vinyl, cellulosics, styrenes and Saran, in most sizes and materials.

Pyramid Plastic Extrusions are now being used in thousands of products because of their cost and functional features. If you are using plastics, it will pay you to check your designs and investigate the savings possible by using Pyramid Plastic Extrusions.

PPI

Send specifications for engineering recommendations and quotation

PYRAMID PLASTICS, INC.

554F West Polk Street • Chicago 7, Illinois

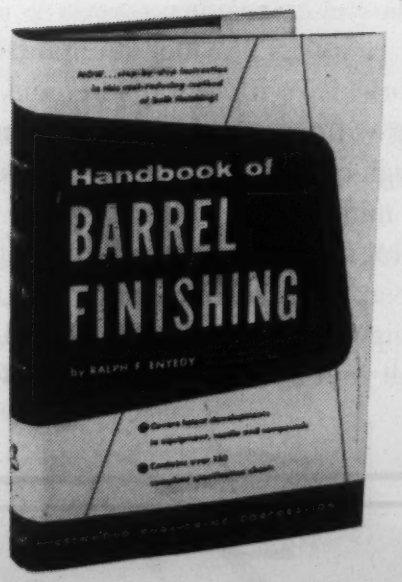
For more information, turn to Reader Service Card, Circle No. 334

Complete information on this cost saving finishing method . . .

Handbook of BARREL FINISHING

by RALPH F. ENYEDY

Industrial Engineer, Electronic Tube Division, Westinghouse Electric Corp., Elmira, N. Y.



Here for the first time in book form are the complete details of this precise, economical method of finishing metal and plastic parts!

Every phase of barrel finishing from cleaning and deslugging to coloring, polishing and burnishing is covered in step-by-step sequence. More than 150 complete specification sheets provide all the information necessary for finishing a large variety of parts.

Latest developments in equipment, finishing compounds and methods are described in full detail. Much of the information on such operations as preparation of metals for sealing to glass, deburring of screw machine parts and multibarrel processing has never before appeared in print.

1955, 288 pages, 7" x 10", $7.50

Order now for 10 days' FREE EXAMINATION

REINHOLD PUBLISHING CORPORATION

Dept. M-901, 430 Park Avenue, New York 22, N. Y.

For more information, turn to Reader Service Card, Circle No. 484

Meetings and Expositions

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS, winter general meeting. New York. Jan. 30-Feb. 3, 1956.

AMERICAN WELDING SOCIETY, Midwest Welding Conference. Chicago. Feb. 1-2, 1956.

SOCIETY OF THE PLASTICS INDUSTRY, Annual Reinforced Plastics Div. Conference. Atlantic City, Feb. 7-9, 1956.

AMERICAN INSTITUTE OF MINING & METALLURGICAL ENGINEERS, annual meeting. New York. Feb. 20-23, 1956.

AMERICAN SOCIETY FOR TESTING MATERIALS, committee week. Buffalo, N. Y. Feb. 27-Mar. 2, 1956.

SOCIETY OF AUTOMOTIVE ENGINEERS, passenger car, body and materials meeting. Detroit. Mar. 6-8, 1956.

NATIONAL ASSN. OF CORROSION ENGINEERS, annual conference and exhibition. New York. Mar. 12-16, 1956.

AMERICAL SOCIETY OF MECHANICAL ENGINEERS, Aviation Div. Conference. Los Angeles. Mar. 14-16, 1956.

STEEL FOUNDERS' SOCIETY OF AMERICA, annual meeting. Chicago. Mar. 18-20, 1956.

AMERICAL SOCIETY OF MECHANICAL ENGINEERS, spring meeting. Portland, Ore. Mar. 18-21, 1956.

SOCIETY OF AUTOMOTIVE ENGINEERS, national production meeting and forum. Cleveland. Mar. 19-21, 1956.

AMERICAN SOCIETY OF TOOL ENGINEERS, industrial exposition, Chicago. Mar. 19-23, 1956.

SOCIETY OF AUTOMOTIVE ENGINEERS, aeronautic meeting, production forum and aircraft engineering display. New York. Apr. 9-12, 1956.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS, Machine Design Div. Conference. Worcester, Mass. Apr. 10-11, 1956.

METAL POWDER ASSN., annual meeting and metal powder show. Cleveland. Apr. 10-12, 1956.

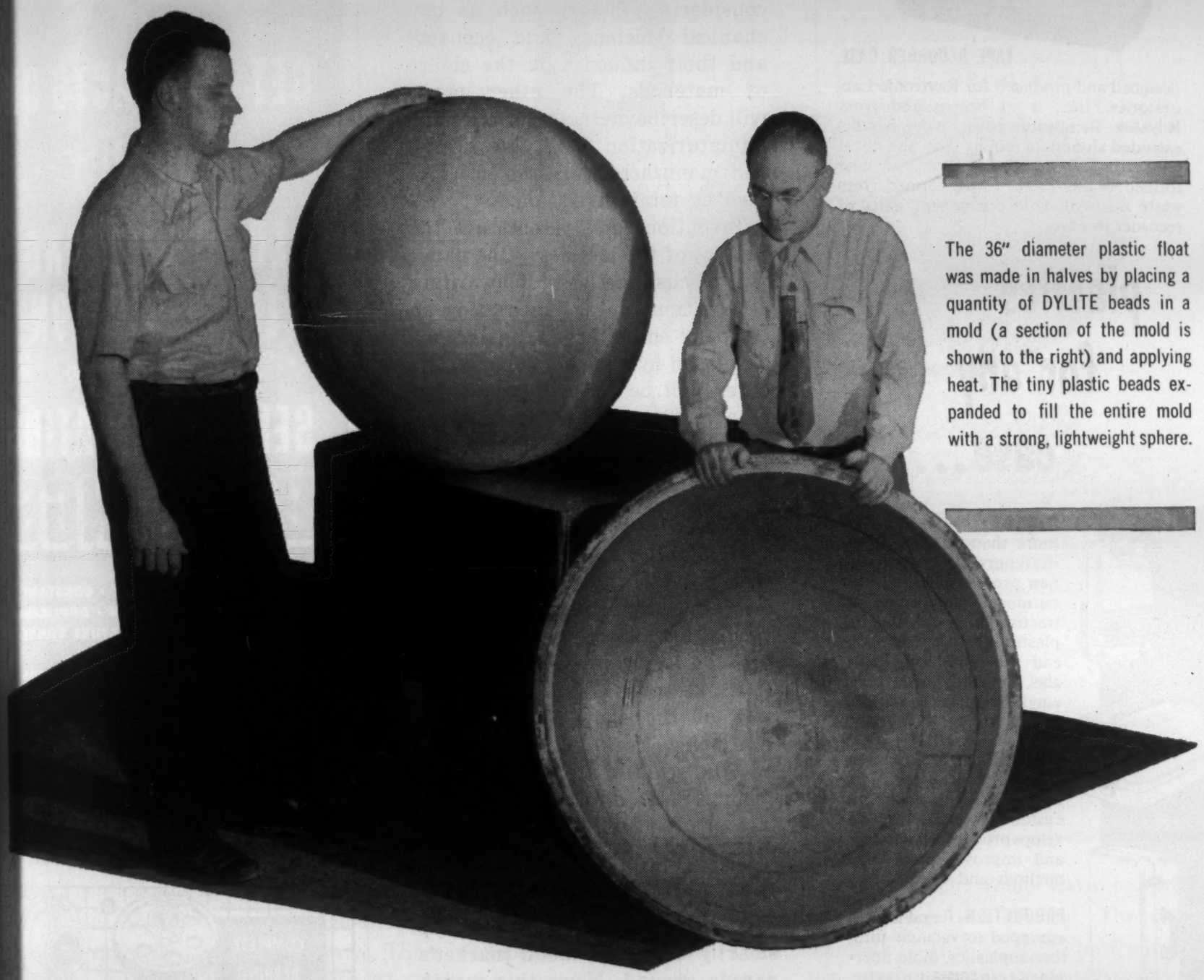
MALLEABLE FOUNDERS' SOCIETY, annual market development conference. Chicago. Apr. 12-13, 1956.

AMERICAN FOUNDRYMEN'S SOCIETY, annual convention and exhibition. Atlantic City, N. J. May 3-9, 1956.

AMERICAN WELDING SOCIETY, national spring meeting and 4th welding and allied industry exposition. Buffalo, N. Y. May 8-11, 1956.

DESIGN ENGINEERING SHOW, exposition and conference. Philadelphia. May 14-17, 1956.

Unsinkable 42-pound Dylite* plastic float supports 20 times its own weight!



The 36" diameter plastic float was made in halves by placing a quantity of DYLITE beads in a mold (a section of the mold is shown to the right) and applying heat. The tiny plastic beads expanded to fill the entire mold with a strong, lightweight sphere.

The Navy needed a tough, lightweight float to support equipment weighing over 800 pounds. Additional requirements: the float must withstand a fall into the ocean, be easy to fabricate and float indefinitely.

After careful consideration, Navy scientists chose DYLITE expandable polystyrene for the float.

DYLITE, the new foamed plastic introduced 18 months ago by Koppers, has found many unusual applications. Tests have shown this extremely lightweight material ideal as a buoyancy agent. It is strong, waterproof, resilient, easy to mold into any shape required, is virtually unsinkable and low in cost.

For more information write to the Koppers Company, Inc., Chemical Division, Dept. MM-16, Pittsburgh 19, Pennsylvania. **Koppers Trademark*

KOPPERS

KOPPERS PLASTICS

SALES OFFICES: New York · Boston · Philadelphia · Atlanta · Chicago · Detroit · Houston · Los Angeles

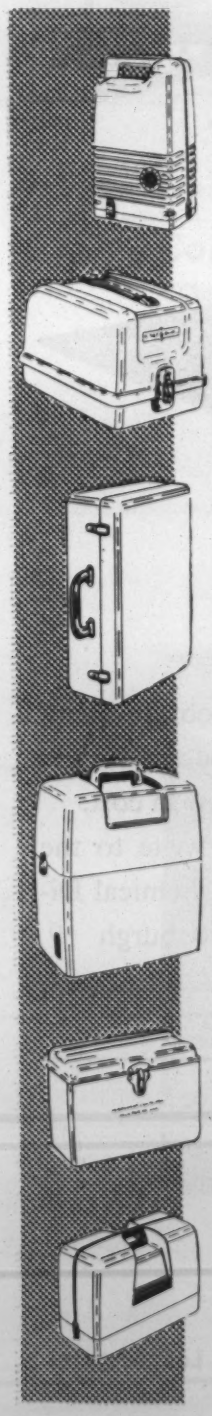
In Canada: Dominion Anilines and Chemicals Ltd., Toronto, Ontario

For more information, turn to Reader Service Card, Circle No. 473

TAPE RECORDER CASE,

designed and produced for Raytronic Laboratories, Inc., is of brown and ivory Royalite. Removable cover; ivory handle; extruded aluminum joining strip and cover edge trim. Insert and bottom of case formed in one piece. Clips, formed from waste material, hold component parts of recorder in cover.

plastics for any case...



DESIGN: From nothing more than an idea, Regal designers develop many new products and redesign outmoded units into attractive ones utilizing the plastic most suited to the end use—Boltaron, Plexiglas, Royalite, polystyrene, vinyl, fiberglass reinforced plastic, etc.

ENGINEERING: Keeping a watchful eye on each job, Engineering works out customers' problems, develops product refinements, and improves production methods and quality.

PRODUCTION: Regal is well-equipped to vacuum form thermoplastics, mold fiberglass reinforced plastic, and produces single parts as well as complete assemblies.

Regal offers *complete service*—from design and development to finished part, product or assembly. Take advantage of Regal's *free design, development, engineering and estimating service* in adapting your products to plastic.

Write for details today!

REGAL
PLASTIC COMPANY
2800 E. 14th St.
Dept. MM-156
Kansas City, Mo.
'Phone: BEnton 1-4080
Representatives in principal cities.

For more information, Circle No. 477

MATERIALS ENGINEERING NEWS

Continued from p. 13

with problems relating to the selection of engineering materials, considering factors such as mechanical efficiency and economy and their influence on the choice of materials. The other paper will describe methods for effecting miniaturization and the design and manufacturing problems created by miniaturization.

Inventions and patents are the subject of the last day. One paper will discuss methods of awarding recognition and compensation to company employees for inventions developed by such employees. The other will be a legal explanation by an outstanding patent attorney of the rights of an employee in his inventions.

On the floor of the show, approximately 150 companies will exhibit materials and components that go into the manufacture of original equipment and other hard goods. Advance registration cards for the show may be obtained from Clapp & Poliak, Inc., sponsors of the show, 341 Madison Ave., New York 17. Information on the conference is available from ASME or Clapp & Poliak.

Aluminum News Roundup

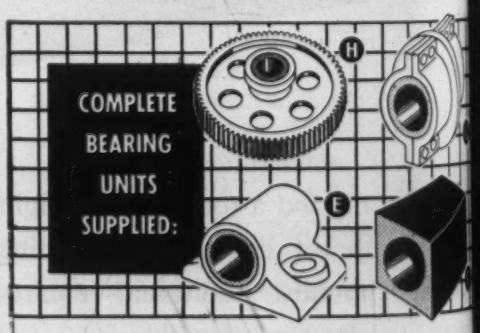
Aluminum continues to step smartly down the metal market's parade ground. News this month includes market statistics, invasion of new markets, an aluminum dry cell, and improvements in sand castings.

In a study made by the Aluminum Association, nearly half of the total of aluminum wrought products shipped in the first half of 1955 were traced to use in building materials, consumer durable goods, and transportation equipment. End use shipments broken down statistically went for the following: building materials, 19%; transportation equipment, 17%; and consumer goods such as household appliances and furniture, 13%. Other categories which include distributors and jobbers,

GET THE FACTS ON
GRAPHALLOY
LONG WEARING
LOW FRICTION
UNIQUE (OIL-FREE)
SELF-LUBRICATING
BUSHINGS

EXCELLENT DURABILITY • CONSTANT COEFFICIENT OF FRICTION • APPLICABLE OVER A WIDE TEMPERATURE RANGE (−450° to +700°F.) OPERATE DRY, OR AT HIGH SPEEDS SUBMERGED IN WATER, GASOLINE OR LIQUID GASES • NON-CONTAMINATING IN FOODSTUFFS • EXCELLENT FOR CURRENT-CARRYING BEARINGS

GRAPHALLOY is widely used for self-lubricating piston rings, seal rings, thrust and friction washers, pump vanes.



BRUSHES • CONTACTS

GRAPHALLOY has high-performance electrical properties: *low electrical noise, low and constant contact drop, high current density, minimum wear!*

Brush Holders and Assemblies, Coin Silver Slip Rings and Assemblies available.

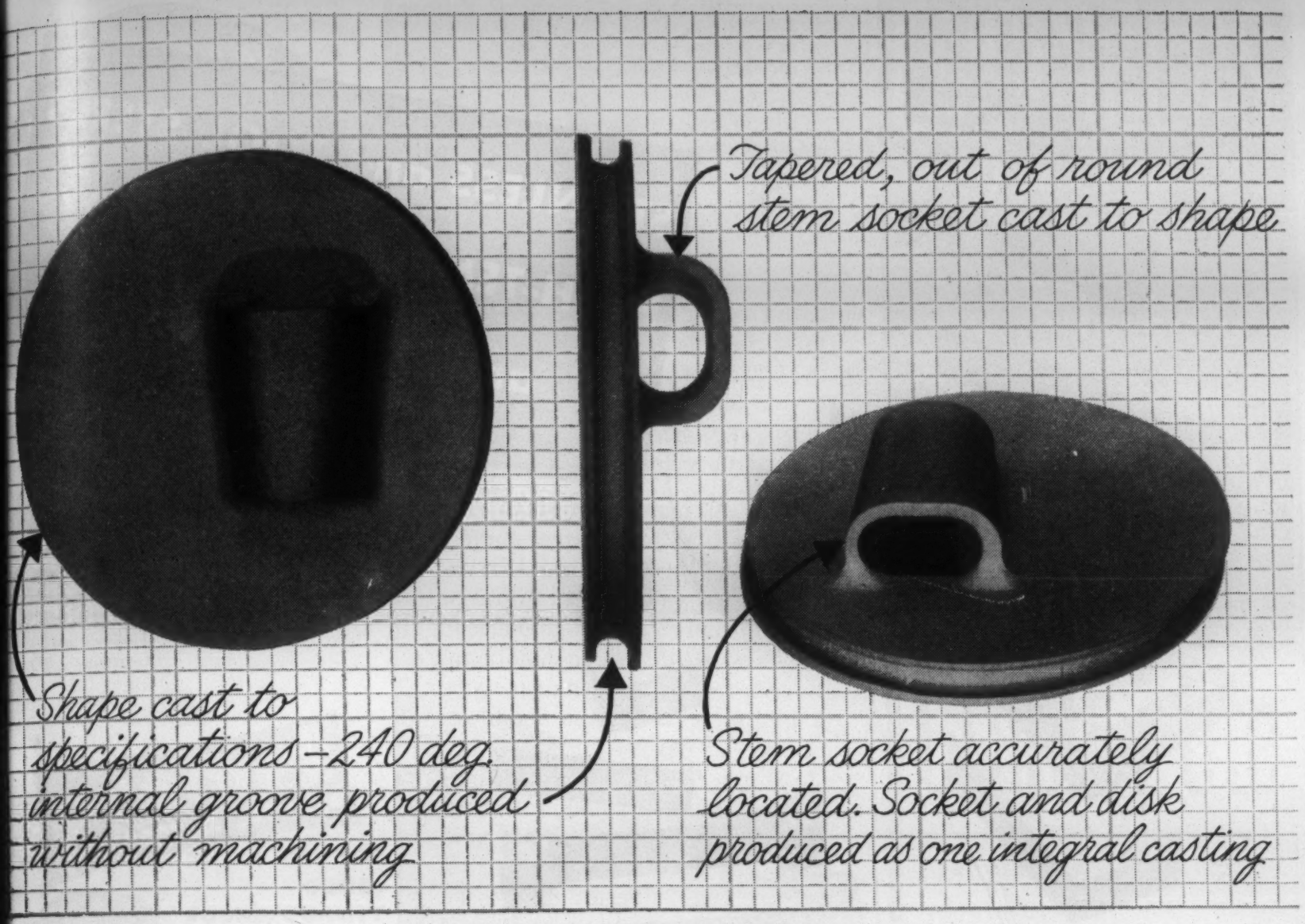
USE OUR 40 YEARS OF DESIGN EXPERIENCE!

GRAPHITE METALLIZING CORPORATION
1010 Nepperhan Ave. • YONKERS, NEW YORK

☐ Please send data on Graphalloy Oil-Free BUSHINGS
☐ Send data on BRUSHES and CONTACTS.

NAME & TITLE
COMPANY
STREET
CITY ZONE STATE

For more information, Circle No. 442



Investment-Cast in One Piece . . .

5 Secondary Operations Avoided

This intricate valve disk and stem socket were investment cast at a considerable saving in machining, assembling, and joining costs. The disk is produced in an odd shape and has a concave rim with a 240-degree groove. There is a tapered, out-of-round recess in the stem socket. The disk and socket were designed and produced as one integral casting.

The shape of the disk, vital to the proper functioning of the part, was cast to size. A contour machining operation would have been required to produce this shape by other methods. The groove in the rim of the disk, and the stem socket, were also cast to size . . . thus eliminating two more difficult machining operations.

An assembly operation, which would have required precision locating devices, was also avoided. The stem socket had to be accurately located . . . 0.225 in. from the centerline of the disk. This location was held to within plus or minus 0.005 in. on the finished part by the investment-casting method.

Reducing production costs by eliminating secondary operations is only one of the many advantages of HAYNES' precision-investment-casting process. For the full story call or write to any of the District Sales Offices listed below:

HAYNES TRADE-MARK ALLOYS

HAYNES STELLITE COMPANY

A Division of Union Carbide and Carbon Corporation

UCC

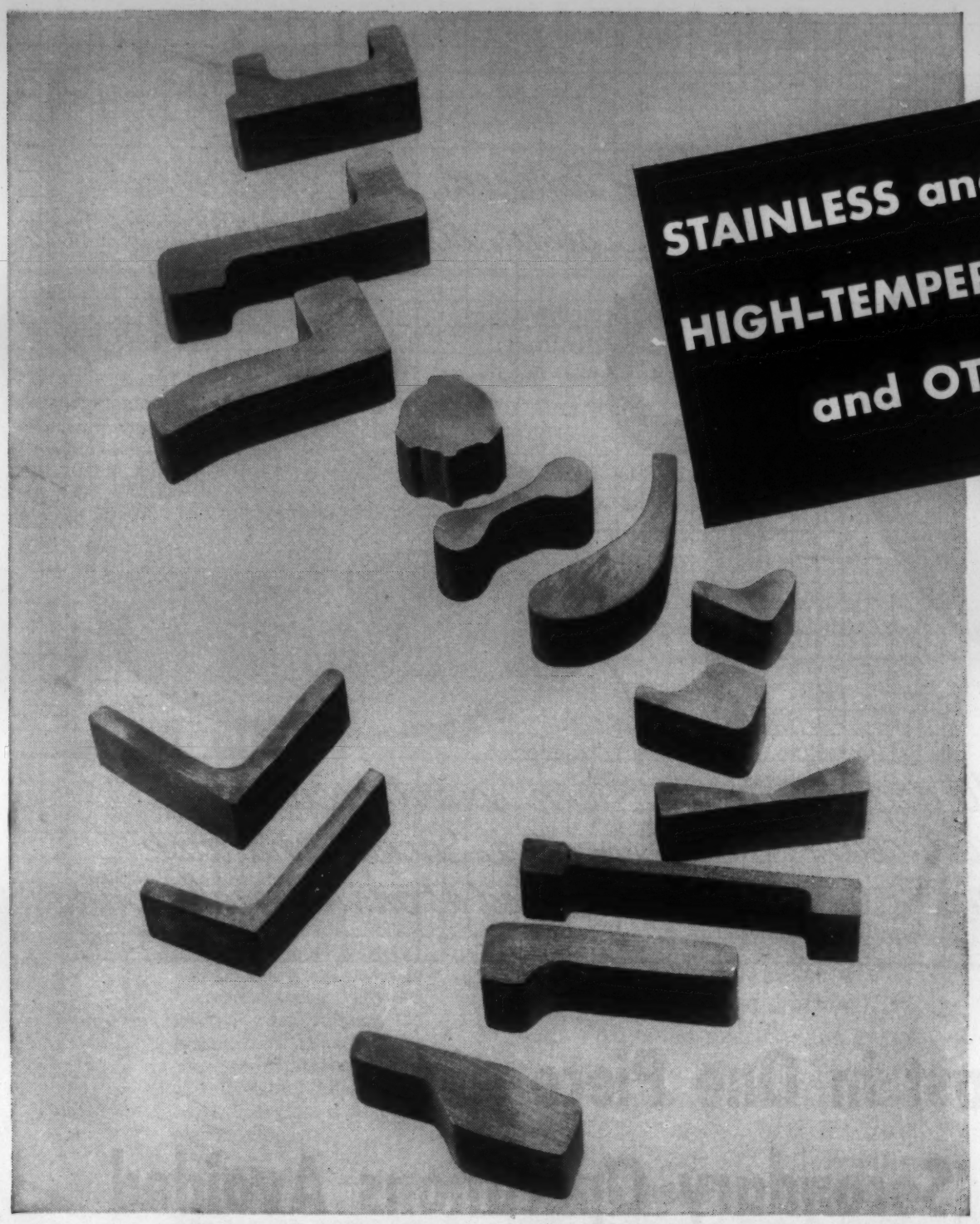
General Offices and Works, Kokomo, Indiana

Sales Offices

Chicago · Cleveland · Detroit · Houston · Los Angeles · New York · San Francisco · Tulsa

"Haynes" is a registered trade-mark of Union Carbide and Carbon Corporation

For more information, turn to Reader Service Card, Circle No. 343



STAINLESS and TOOL STEELS
HIGH-TEMPERATURE ALLOYS
and OTHER STEELS

A-L HOT EXTRUSIONS (solid and hollow) may solve problems for you

Help! (Dept. MM-73)

We have a parts problem that hot extrusions might solve. Let's see an AL representative for facts and figures.

- ☐ STAINLESS STEEL
- ☐ TOOL STEEL
- ☐ HIGH TEMPERATURE STEEL
- ☐ OTHER STEELS

Name_____

Company_____

Address_____

Where can these leading advantages of hot-extruded special alloy steels apply to your production?

1. Hot extrusions require very little finishing before use, even in the case of involved shapes. The scrap loss is small and you can buy raw materials closer to finish size. You buy less high-cost steel, cut away less of it . . . save both in time and material cost.

2. The range of shapes, solid or hollow, which can be hot-extruded is almost infinite. They can be easily and quickly produced in any quantity. Dies for new or experimental parts cost little and can be made up fast.

● We're ready to serve your needs with hot extrusions in any grade of stainless or high temperature steel, many tool steel grades and other steels. Call us in to help. ***Allegheny Ludlum Steel Corporation, Oliver Building., Pittsburgh 22, Pennsylvania.***

Leading Producer–High Alloy Steels

Allegheny Ludlum

AL® TIME-TESTED STAINLESS STEEL

WAD 5318

For more information, turn to Reader Service Card, Circle No. 423

AMERICAN CRUCIBLE knows Bearings!

Send Prints for Quotation

When you are looking for bearings, bushings and wearing parts that will stay on the job and give trouble-free service— SWITCH TO

Promet Engineered Bronze

GET THE GOOD, SOUND QUALITY THAT ASSURES EXCELLENT PERFORMANCE

Discuss your bearing problems with our metallurgists, engineers, and laboratory technicians. This service will in no way obligate you. Write for free literature and service data sheets or send blueprints, conditions of operation and data for recommendations and quotations.

PROMET

THE American Crucible PRODUCTS CO.

"Bearing Specialists Since 1919"

1325 Oberlin Avenue Lorain, Ohio, U.S.A.

Please send free literature and service data sheets on Promet Bronze.

NAME_____

COMPANY_____

STREET_____

CITY & STATE_____

For more information, Circle No. 389

MATERIALS ENGINEERING NEWS

industrial machinery, and exports accounted for 49%.

Direct sales to military agencies and orders for AEC constituted 2% of total end-use shipments of wrought products, while 22% of sand castings shipped and 5% of permanent mold castings were scheduled for national defense.

New design concepts

Wide extrusions of aluminum are the latest market spearhead according to Harvey Aluminum. Because of design versatility and functional adaptability, wide extrusions can be used in redesigning numerous existing structures and structural sections. Design engineers can obtain shapes to the desired finished section by combing components into one integral unit. Built-up sections are eliminated and assembly and production time reduced. Material distribution is such that considerable weight is saved and strength is increased.

To illustrate a typical application for wide extrusions, Harvey points to a cost comparison of a wooden scaffold board versus an aluminum section of the same dimensions. A check revealed that initially, the cost of manufacturing a wooden board was lower than one made of aluminum. However, when combining the initial cost with the longevity of each scaffolding, the aluminum board ran 50% less in cost than the wooden one. Factors that influenced cost were labor charges for erection and disassembly and the cost of maintenance and repair. The weight of the wooden board was 75 lb and required two men to set up and dismantle; the comparable aluminum plank weighed 25 lb and was handled by one man.

Dry cell batteries

Continuing aluminum's frontal assault on new market areas is Alcoa's development of an aluminum dry cell battery with a long shelf life. Not yet in the production stage, the aluminum cell ap-

ENGINEERS

- RESEARCH
- DEVELOPMENT
- PROCESS
- METALLURGICAL

NOW YOU CAN HANDLE CORROSIVES AT TEMPERATURES UP TO 5700°F WITH

Graph-i-tite

PROPERTIES	"Graph-I-Tite" A	"Graph-I-Tite" G
Apparent Density (lbs/ft³)	118	115
Tensile Strength (PSI)	2600	2500
Compressive Strength (PSI)	9000	8500
Transverse Strength (PSI)	4800	4400
Modulus of Elasticity (x 10^5)	21	18
Thermal Expansion (In/In/°F x 10^{-7})	11	9
Electrical Resistance (ohm-inches)	.00042	.00035
Thermal Conductivity (BTU/sq. ft/°F/hr/in)	1000	1100
Max. Temperature Resistance	1300°F	5700°F

GRAPH-I-TITE is a carbon-impregnated graphite. It is impermeable . . . non-wettable . . . non-contaminating . . . unaffected by thermal shock...Can be formed into pipe, cylinders, crucibles, molds, nozzles, and special shapes . . . Is immune to even the attack of dry chlorine at temperatures of 5000°F. . . . will provide rocket nozzle inserts of low erosion rates . . . may be produced sufficiently pure for use in atomic piles for transfer of fluids or heat and as a moderator.

Also, custom formulated graphite can be produced to meet your special purity, density, or other specifications. Extrusion, molding and machining facilities are available for one piece or high production runs.

Don't let old-fashioned materials restrict your thinking. Write today for additional information, and engineering help, if desired.

GRAPHITE SPECIALTIES CORP.
64th STREET AND PINE AVENUE
NIAGARA FALLS, N. Y.

For more information, Circle No. 351

MATERIALS & METHODS

The Magazine of Engineering Materials

is looking for

AN EDITOR

to add to its staff in New York.

An interesting career in technical journalism awaits a man who has the necessary background and interests to fit the needs of MATERIALS & METHODS.

Ideally, the man will have had an engineering education, probably mechanical or electrical, plus a few years in industry. An interest in writing, editing and travel are essential. We are not necessarily looking for a trained writer, but we do want a man who knows how — and likes — to write clearly, accurately and interestingly.

If you feel that you can meet these specifications, please write, including your education, and work experience, age, marital and martial status, references and what you expect in the way of salary. If possible, include samples of any of your published writings.

Address all communications to:

T. C. Du Mond, Editor

MATERIALS & METHODS

430 Park Avenue, New York 22, N. Y.

pears comparable to conventional zinc batteries and could be used interchangeably in all equipment designed for the zinc battery. Utilizing the attractive properties of aluminum, low electrochemical equivalent and high electrode potential, the aluminum battery has a potential of 1.6 to 1.7v.

Castings improved

Castability of aluminum alloys can be improved by adding a titanium-aluminum hardener developed by Shieldalloy Corp. Fluidity is increased, with a consequent decrease in pin holes and hot tearing, and because porosity is greatly reduced, castings have shown an increased resistance to pressure and will hold fluids without leakage. The addition of the intermediate alloy also prevents hot cracking, alleviating a major source of trouble in foundry practice.

The 5% titanium addition dissolves easily in molten aluminum. One of the beneficial effects of the addition is that much smaller grain sizes can be obtained at lower casting temperatures than by super heating. This finer grain structure produces an increase in strength of 10 to 25% together with an increase in ductility.

Stainless Now Second Most Popular Steel, Survey Shows

A recently completed survey of readers of MATERIALS & METHODS shows that the ferrous metals are by far the most widely used engineering materials. The survey shows that one or more forms of iron and steel are used by 98.6% of the plants covered by the survey.

One of the most surprising facts revealed by the survey is that stainless steel has reached the number two position among steels insofar as variety of uses is concerned. Carbon steels, of course, still maintain their position of

MATERIALS ENGINEERING NEWS

leadership. Carbon steels are used in 87.5% of the plants and stainless steels in 78.3%.

Complete rankings of the major steel groups show the following degree of acceptance:

Carbon steels	**87.5%**
Stainless steels	**78.3**
Tool steels	**61.0**
Low alloy steels	**58.4**
High alloy steels	**57.3**

In analyzing the shapes in which steels are used, it was found that rods and bars accounted for a high proportion of the use of all steels. It is interesting to observe that the relatively new extruded shapes in carbon steels are being used by 8.8% of the plants covered by MATERIALS & METHODS. The figure for extrusions compares with 27.6% forgings and 30.0% castings.

In examining the relative uses of irons, the survey found that gray iron still held a substantial lead over other irons as well as over cast steels.

Irons and their relative uses are shown in the following table:

Gray iron	**47.5%**
Malleable iron	**31.0**
Ductile or nodular iron	**19.2**
Wrought iron	**13.0**

Answers to the survey were broken down into industry groups to determine to what extent the major industrial groups used steels. The ratings follow:

Ordnance	**94.7%**
Machinery (other than electrical)	**92.5**
Fabricated metal products	**89.7**
Transportation equip	**89.6**
Instruments	**88.1**
Elect machinery and equip	**86.3**
Misc mfg industries	**70.8**

One of the purposes of this and other surveys to be reported on soon is to learn the major interests of MATERIALS & METHODS readers, in order that the most suitable editorial program can be planned.

(More News on p. 218)

Available Now!!

Reprints of

MATERIALS & METHODS MANUALS

Because of the great demand for the well-known Manuals that are being widely used for reference purposes, we have reprinted the following MATERIALS & METHODS Manuals for your use. These outstanding 16- to 32-page articles provide you with complete and useful information on the properties, characteristics and uses of engineering materials, parts and finishes.

The price is right! Only 25¢ for each reprint. On orders of 100 or more, an even greater saving is offered—20¢ apiece. To obtain your copies, indicate in the handy coupon below the Manuals you want. Orders will be filled as long as the supply lasts.

Would you prefer receiving these valuable Manual reprints automatically each month in the future? If you are a subscriber to MATERIALS & METHODS, then avail yourself of a new service recently instituted by our Reader Service Department. Let us add your name to our mailing list, and you will receive the next 12 Manual reprints, one each month, for the same reasonable price of $3.00 per year. Just fill in the coupon below and mail it to:

Reader Service Department
MATERIALS & METHODS
430 Park Avenue
New York 22, New York

▼ Quantity	▼ Quantity
....Compression Molded Plastic Parts	....Close Tolerance Castings
....Wrought Phosphor Bronzes	....Age Hardening of Metals
....Carbon and Low Alloy Steel Castings	....Adhesive Bonding
....Carburizing of Steels	....Clad and Precoated Metals
....Welded and Brazed Parts	....Wrought Non-Leaded Brasses
....Malleable Iron Castings	....Silicones—Properties & Uses
....Welding the Stainless Steels	....Short Run Press Formed Parts
....Rubber Parts	....Metals for Short Time Service at High Temperature
....Wood and Wood-Base Materials	....Improving Product Quality Through Better Materials
....Surface Hardening of Steels and Irons	....Finishes for Plastics
....Selecting Metal Cleaning Methods	....How to Select a Wrought Steel
....Engineering Coppers	....Impact Extruded Parts
....High-Strength, Low-Alloy Steels	....Finishes for Metal Products
....Sandwich Materials	....Nodular or Ductile Cast Irons
....Materials for High Temperature Service	....Corrosion: How It Affects Materials Selection and Design
....Rigid Polyvinyl Chloride Plastics	....Industrial Textile Fibers
....Mechanical Properties & Tests of Engineering Materials	....Wrought Aluminum Alloys
....How Nuclear Radiation Affects Engineering Materials	

Name .....Title .....

Company .....

Street .....

City .....State .....

☐ Yes, I am a subscriber to MATERIALS & METHODS and would like to be put on your mailing list to receive each future Manual, when reprinted. Please start it with the.....issue. Upon receipt of your invoice, I will pay $3.00 for a year's supply.

For more information, Circle No. 412

MATERIALS ENGINEERING NEWS

Plastics Engineers To Meet in January

Keynoting the Society of Plastics Engineers Conference to be held Jan. 18 to 20, 1956, at the Statler Hotel in Cleveland is the theme "Plastics Progress Presents". Daily movie films of the industry and a showing on Wednesday of the new Du Pont Polychemicals Sales Service Laboratory by closed circuit television from Wilmington are some of the highlights of the conference.

Epoxy resins are up for comment and papers will discuss the long term properties of reinforced epoxy pipe and the use of these resins for effecting durable high strength bonds as metal to metal and metal to core adhesives for the aircraft industry.

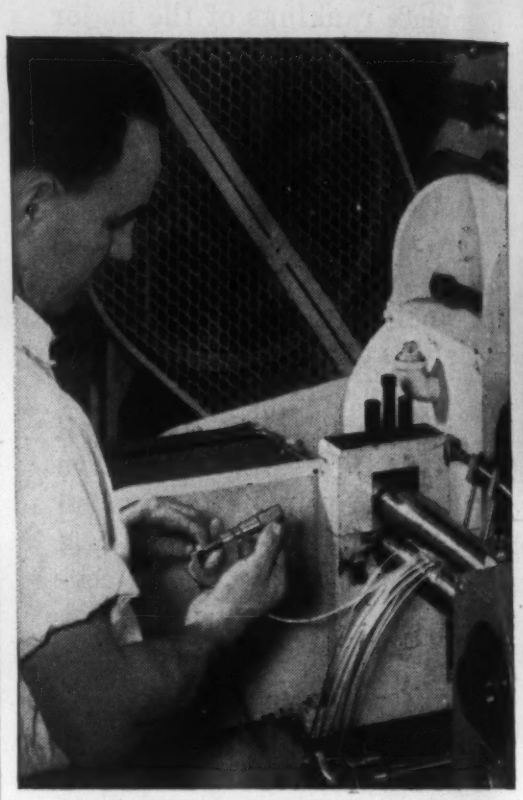
Turning to the high polymer field, conferees will learn of the effects of radiation on polystyrene, nylon, acrylics, and polyethylene. The production of a variety of graft copolymers by irradiation of polymers in the presence of a monomer are a byproduct of this research.

The ticklish problem of establishing reliable test standards is also slated for review. Impact testing as a criterion of toughness for styrene rubber molding materials and a modification of Izod impact testing to permit evaluation of film and molded tensile bars are on the program agenda.

Among the other varied subjects to be treated during the three day plastics conference, the following are of special interest: nonglass reinforcement in plastics, asbestos reinforced plastic laminates, polyurethane foams, vinyl foam, super-polyethylenes, fabrication methods and applications of expanded polystyrene, and the effects of fabrication on the properties of "Teflon" tetrafluoroethylene resin.

For more information, Circle No. 316

for exacting standards only



Not one strip rolling requirement in ten need be carefully "miked" to assure close width tolerance.

But that exceptional job is routine with Somers THIN STRIP. Monel, pure Nickel and Nickel alloys are rolled to within ±5% from .010" to .00075", with the same degree of accuracy in widths, and with the exact properties required by your product.

Modern rolling, annealing and precision control equipment assure uniform high quality under the most rigid specifications.

And Somers 40 years experience in a wide range of applications is available to help solve your strip problem without obligation.

Write for confidential data blank or field engineer.

FOR EXACTING STANDARDS ONLY
Somers
Somers Brass Company, Inc.
WATERBURY, CONN.

For more information, Circle No. 456

FOR SCUFF-RESISTANT BEAUTY. This Sunroc water cooler has, as standard equipment, a Stainless Steel kick plate for protection against scuffing and corrosion when floors are mopped. The deep drawn top is also made from Stainless. It's bright and inviting, and easy to clean.

FOR LONG, HARD SERVICE. Some of the Stainless Steel tubes in this bundle are 20 years old, despite the fact that they have been in continual service in a thermal cracking unit at a major southwestern oil refinery. Even though some of them have been lengthened by heliarc welding, they still retain their ability to handle corrosive products.

NOTHING *can equal* *Stainless Steel*

FOR SANITATION. This is a Stainless Steel rotary washer at a baby food plant of Gerber Products Company. Stainless Steel was used because of its great corrosion resistance, because it will not contaminate the food products, because it is so very easy to clean. Gerber's uses a lot of Stainless Steel processing equipment—including peelers, bins, steamers, holding tanks and filling machines.

• No other design material can match Stainless Steel in its *combination* of desirable properties: corrosion resistance, strength and hardness, beauty, cleanability and easy fabrication. When seeking a source of supply, remember that United States Steel offers the widest range of types, finishes and sizes available in the United States.

UNITED STATES STEEL CORPORATION, PITTSBURGH • AMERICAN STEEL & WIRE DIVISION, CLEVELAND
COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO • NATIONAL TUBE DIVISION, PITTSBURGH
TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA.
UNITED STATES STEEL SUPPLY DIVISION, WAREHOUSE DISTRIBUTORS
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

USS STAINLESS STEEL

SHEETS · STRIP · PLATES · BARS · BILLETS
PIPE · TUBES · WIRE · SPECIAL SECTIONS

USS

UNITED STATES STEEL

Tempilstik°

FOR ALL HEAT-DEPENDENT OPERATIONS

looks like a crayon... marks like a crayon... tells temperatures like a precision instrument!

Sixty-three different compositions enable you to determine and control working temperatures from 113° to 2000° F. TEMPILSTIK° marks on workpiece "say when" by melting at stated temperatures—plus or minus 1%.

Also Available in Liquid and Pellet Form . . . Write **INDUSTRIAL DIV.** for Sample Tempil° Pellets . . . State Temperatures of Interest—PLEASE!

Tempil°
CORPORATION
132 WEST 22ND STREET
NEW YORK 11, N. Y.

For more information, Circle No. 358

LETTERS TO THE EDITOR

Continued from p. 14

way of keeping in touch with latest developments in all fields.

A. J. EGGINGTON
Atomic Energy Research Establishment, Berks, England

To the Editor:

We have in our possession a reprint of Manual 99 which appeared in MATERIALS & METHODS, November, 1953.

We feel that this is an excellent outline of the problems which should be considered in metal cleaning methods. If it is possible at this late date to acquire 50 copies of this manual, we would like very much to have them for distribution to our sales personnel.

J. H. PALMER
Metal Industries Dept.
The Diversey Corp.
Chicago, Ill.

Copies of this manual are still available.

To the Editor:

As you may be aware, we are subscribers to MATERIALS & METHODS and find the contents thereof of considerable value, not merely in connection with our teaching activities, but also in the development of projects for associated companies.

T. W. PADDON
Tutorial Dept.
British Institute of Engineering Technology
London

To the Editor:

Thank you very much for the helpful information submitted in reply to our inquiry.

Let me assure you that we make full use of the copies of MATERIALS & METHODS as well as the manual reprints to which we subscribe. We index articles of interest, refer them to our men, as well as maintaining a regular routing and clipping service. One subscription is bound for future use. We congratulate you on the quality of the periodical and on the pertinent subjects covered.

MIRIAM M. LANDUYT
Research Librarian
Caterpillar Tractor Co.
Peoria, Ill.

REINHOLD BOOKS
for Engineers
FREE EXAMINATION

☐ **INSTRUMENTS FOR MEASUREMENT AND CONTROL** *by Werner G. Holzbock.* Describes and illustrates all recent devices for measuring and controlling temperature, moisture, pressure, flow, uniformity, etc. Discusses the design, construction and operation and comparison factors to consider in choosing the proper instrument for a particular job. 1955, $10.00

☐ **TEMPERATURE: *Its Measurement and Control in Science and Industry, Vol. 2*** *edited by Hugh C. Wolfe for the American Institute of Physics.* Records the proceedings of the Third International Symposium on Temperature held October 1954. Presents invaluable new material on techniques determining temperatures from .001°K to the core of an atomic explosion. Includes new revisions in the international temperature scale, techniques of resistance thermometry, use of superconductors and semiconductors, temperatures in non-equilibrium situations, optical measurement methods, measurement in engineering, and much, much more. 1955, $12.00

☐ **MATERIALS FOR NUCLEAR POWER REACTORS** *by Hausner and Roboff.* Describes the basic types of materials used in nuclear power reactors, their functions, and the problems associated with their use. Fully explains the criteria necessary in selecting materials for shielding, for cladding fuel elements, for moderators and reflectors — for all the necessary parts of a reactor. 1955, $3.50

☐ **MATERIALS TECHNOLOGY FOR ELECTRON TUBES** *by Walter H. Kohl.* Treating such materials as glass, ceramics, mica, tungsten, molybdenum, tantalum, copper, nickel and graphite this book is the first in the English language to offer a thorough scientific description of the components of electron tubes and the methods of uniting them, such as glass-to-metal seals. Each chapter dealing with these materials contains an extensive and, in certain cases, a previously unpublished tabulation of their physical characteristics, their chemical reactions with various reagents, and the processes used in their application. 1951, $12.50

☐ **DETERIORATION OF MATERIALS: *Causes and Preventive Techniques*** *edited by Glenn A Greathouse.* Expert information by 24 specialists on what you can do to protect valuable materials and equipment. Describes the nature of deterioration processes and preventive measures to prolong the life of everything from raw materials to finished products. 1954, $12.00

☐ **FABRICATED MATERIALS AND PARTS** *by T. C. DuMond.* A comparison of cost and design factors to help you select the *right* metal-forming methods for the greatest economy in manufacturing small industrial parts. Contains a valuable fold-out chart (over 2½ feet long) showing at a glance the cost, design and production comparisons between various manufacturing methods. This chart alone is worth many times the book's cost to production men. 1953, $6.50

☐ **THE TECHNICAL REPORT: *Its Preparation and Use in Government and Industry*** *edited by B. H. West.* From the conception of its need to final destination and use, *every* phase of the technical report is fully covered. It will prove of great value to any engineer who must prepare or depend on reports for precise communication. 1954, $12.00

☐ **NOMOGRAPHY AND EMPIRICAL EQUATIONS** *by Dale S. Davis.* Explains the many engineering applications and shows how to employ industrially important alignment and line co-ordinate charts to speed up daily on-the-job calculations. 1955, $6.75

☐ **PROBLEMS AND CONTROL OF AIR POLLUTION** *by the Committee on Air-Pollution Controls, ASME.* Based on the papers presented at the First International Congress on Air Pollution by the world's foremost authorities in the field. 1955, $7.50

☐ **BASIC LUBRICATION PRACTICE** *by Allen F. Brewer.* A practical data book for engineers and maintenance men who need to choose and use the most effective lubricant for industrial and power plant machinery. Valuable charts and tabular data give quick comparisons of lubricants for specific machinery under various operating conditions. 1955, $6.75

☐ ***Hawley's* TECHNICAL SPELLER** *by G. G. Hawley.* A quick, convenient guide to thousands of difficult technical words used in physics, electronics, engineering, chemistry, etc. Technical writers and secretaries who take technical dictation will find this book a handy time-saver. 1955, $2.95

☐ **RARE METALS HANDBOOK** *edited by Clifford A. Hampel.* Latest available data on over 30 of the less-common metallic elements — previously little investigated but now playing most important roles in modern technology. Information on each element is arranged for quick reference to such important aspects as occurrence, production statistics, economics, derivation, physical and chemical properties, fabrication techniques, alloys and applications. 1954, $12.00

CHECK AND MAIL TODAY

REINHOLD PUBLISHING CORPORATION
Dept. M-892, 430 Park Ave., New York 22, N.Y.

Please send me the books checked above for 10 days' FREE EXAMINATION.

NAME_____
(Please Print)

ADDRESS_____

_____

For more information, Circle No. 432